International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:4, No:8, 2010

How to Win Passengers and Influence Motorists? Lessons Learned from a Comparative Study of Global Transit Systems

Oliver F. Shyr, Yu-Hsuan Hsiao, David E. Andersson

Abstract**—**Due to the call of global warming effects, city planners aim at actions for reducing carbon emission. One of the approaches is to promote the usage of public transportation system toward the transit-oriented-development. For example, rapid transit system in Taipei city and Kaohsiung city are opening. However, until November 2008 the average daily patronage counted only 113,774 passengers at Kaohsiung MRT systems, much less than which was expected. Now the crucial questions: how the public transport competes with private transport? And more importantly, what factors would enhance the use of public transport? To give the answers to those questions, our study first applied regression to analyze the factors attracting people to use public transport around cities in the world. It is shown in our study that the number of MRT stations, city population, cost of living, transit fare, density, gasoline price, and scooter being a major mode of transport are the major factors. Subsequently, our study identified successful and unsuccessful cities in regard of the public transport usage based on the diagnosis of regression residuals. Finally, by comparing transportation strategies adopted by those successful cities, our conclusion stated that Kaohsiung City could apply strategies such as increasing parking fees, reducing parking spaces in downtown area, and reducing transfer time by providing more bus services and public bikes to promote the usage of public transport.

Keywords**—**Public Transit System, Comparative Study, Transport Demand Management, Regression

I. INTRODUCTION

TAIWAN is a country which has 2,300 million populations and high private transports rate. She owns more than 5.7 million cars and 15 million motorcycles. As the oil prices increasing and the conscious of environmental are higher, many countries are now devoted to find replaceable energy; especially in the transportation industry, which consume a large proportion of energy. Transportation in energy demand and environment impact has a bad influence that causes many countries to have to pay the highest transportation cost. Among these alternatives, transit-oriented development (TOD) has become an effective strategy to create compact and mix use of land cities. And Taiwan is no exception.

Assistant professor, Department of Urban Planning, National Cheng Kung University, Tainan, Taiwan (phone: +886-6-2757575#54241 ,e-mail: oliver.shyr@livemail.tw)

Graduate student, Department of Urban Planning, National Cheng Kung University, Tainan, Taiwan

Assistant professor, Institute of Public Affairs Management, National Sun Yat-sen University, Kaohsiung, Taiwan (phone: +886-7-2555581 ,e-mail: david@faculty.nsysu.edu.tw)

Inspired by the success of Mass Rapid Transit (MRT) System in Taipei, Kaohsiung launched its MRT project in 2002 and completed her two-line system in September, 2008. So far, the operators of MRT are very disappointed at the fact that the percentage of commuters by public transit slightly increases from 5% to 9.6%. On the other hand, the percentage by private transports remains as nearly as 50% in Kaohsiung. Kaohsiung city has a good environment and the climate makes the motorcycles are quite welcome because they are much cheaper, easier to reach the destination, easier to park and swifter in jammed traffic. Despite all these advantages, scooters are a dangerous mode of transport because it's higher accident rates. What's more, they are responsible for the majority of collision-related injuries and casualties. Yet it seems that Taiwanese are willing to take the risks. Nevertheless, transit is often preferred by planners because of its efficiency and sustainability while mobile scooters, due to its constant conflicts with pedestrians and bicycles, do not seem to fit in with the concept of TOD.

To promote TOD, city planners recently introduced reliable yet expensive public transit system. Now the crucial question: Is it cost-effective? How can public transport competitive with other private transport? In addition, what are the incentives and strategies to promote TOD in Taiwan cities other than Taipei? And most importantly, what are the key factors to promote the use of public transportation? To answer these questions, our study had conducted a comparative study on transit ridership using a sample of 71 cities worldwide. First, by applying multivariate analysis methods such as regression analysis and descriptive statistics, not only the cause and effect of factors related to transit ridership can be interpreted, but also the relationship among transit ridership, commuting behavior, land use density, and other socio-economic characters can be clarified through our sample metropolitan areas. Next, our study seeks for successful and unsuccessful examples in cities with high and low transit usage. Based on the comparative analysis, the key factors of success regarding TOD strategies under various urban patterns can be identified. In conclusion, our study offers suggestions regarding proposals of feasible TOD strategies for two Taiwanese cities based on the comparative study of cities with commuting behavior similar to our cities. As for future direction of research, the main concern is to extend the scope of study to include quantitative data regarding all urban modes of green transports and to expand our sample cities to obtain more reliable estimates of regression models. Meanwhile, it is very crucial to monitor the impacts of these proposed actions upon commuting behavior as the input for future evaluation of the effectiveness of these proposals.

II. What Are The Factors Affecting Transit Patronage?

There are quite a few of researchers that had been studying the problem over the last decade. A study by Taylor, etc [1] had been conducting a cross-sectional analysis of transit use in 265 US urbanized areas and testing dozens of variables measuring regional geography, metropolitan economy, population characteristics, auto/highway system characteristics, and transit system characteristics. By constructing two-stage simultaneous equation regression models to account for simultaneity between transit service supply and consumption, their study concluded that most of the variation in transit ridership among urbanized areas can be explained by factors outside of the control of public transit systems: 1) regional geography (specifically, area of urbanization, population, population density, and regional location in the US), 2) metropolitan economy (i.e., personal/household income), 3) population characteristics (i.e., the percent college students, recent immigrants, and Democratic voters in the population), and 4) auto/highway system characteristics. Additionally, they find that transit policies do make a significant difference. Controlling for the fact that public transit use is strongly correlated with urbanized area size, about 26% of the observed variance in per capita transit patronage across US urbanized areas is explained in the models presented here by service frequency and fare levels. Their observed influence of these two factors is consistent with both the literature and intuition: frequent service draws passengers, and high fares drive them away. Another study by Currie and Wallis [2] provides a synthesis of the evidence on the patronage growth performance of bus improvement measures in urban settings. Their evidence includes a summary of experience in Europe, North America and Australasia focusing on service improvement measures including network structure and service levels, bus priority measures, vehicles and stop infrastructure, fares and ticketing systems, passenger information and marketing, personal safety and security and synergy effects of measures. Their data source is the research literature and documented experienced from a series of studies undertaken by the authors over the last decade. It includes the results of an international bus expert `Delphi' survey concerning bus improvement measures focus on patronage growth. Similar study by Currie and Rose [3] firstly examines barriers to patronage growth before reviewing evidence on endogenous factors (those within the control of operators and regulators) and exogenous factors (those factors such as socio-economic influences which are not controlled by regulators/operators) which affect public transport patronage. Suggested barriers include capacity, network transfers, perceptions and investment/subsidy needs. Evidence is presented suggesting that reliability, service levels and fares are the principal tools to adopt in growing patronage. Car ownership, income and population growth, employment and urban sprawl are amongst the exogenous factors identified as influencing patronage.

All of the above studies examine the endogenous and exogenous factors affecting transit patronage, while Hensher [4] targets the effect of auto ownership on transit patronage in many developed and developing economies. In his study, presented evidence suggested that while some countries are losing public transport modal share, other nations are gearing up for a loss, as the wealth profile makes the car a more affordable means of transport as well as conferring elements of status and imagery of 'success'. Some countries however have begun successfully to reverse the decline in market share, primarily through infrastructure-based investment in bus systems, commonly referred to as bus rapid transit (BRT). His paper also pointed out that BRT gives affordable public transport greater visibility and independence from other modes of transport, enabling it to deliver levels of service that compete sufficiently well with the car to attract and retain a market segmented clientele. As a result, BRT is growing in popularity throughout the world, notably in Asia, Europe and South America, in contrast to other forms of mass transit (such as light and heavy rail). This is in large measure due to its value for money, service capacity, affordability, relative flexibility, and network coverage. Similar conclusion is drawn from the study by Cullinane [5].

The paper presented by Bresson, etc. [6] applies a panel data analysis of annual time series from 1975 to 1995 for 62 urban areas in France. It compares the results obtained from a conventional fixed-effects (FE) model with a Bayesian approach (shrinkage estimators), which allows the computation of elasticities for each urban area. First, considering only three economic determinants (vehicle km, income and price), we show the sensitivity of the estimates to the time period used for the estimation. On the basis of these models, public transport appears as an 'inferior good' (i.e. its income elasticity is negative). By combining economic determinants with structural determinants (i.e. population ageing, urban sprawl and growing car ownership) synthesized in a single indicator, we show that this `income effect' is in fact mainly a 'motorization effect'. The competition with the automobile also appears through the cross-elasticity to the fuel price. Finally, the impact of supply is decomposed into a dominant effect of quantity (seats kilometres), and the weaker effects of quality (frequency and density of network). The major conclusion is that the downward trend in public transport patronage is mainly due to increasing car ownership, and that this effect will be less and less important over time since the growth of the car stock is decelerating. In addition, the use of public transport is quite sensitive to the volume supplied and to its price, which makes the financial equilibrium of this industry problematic.

Similar conclusion is drawn from the study by Dorsey [7]. In this paper, the author evaluates current transportation practices and policies, specifically the costs and benefits of parking versus the application of Unlimited Access programs at American universities. Case studies from universities in Utah illustrate national transportation problems, and demonstrate the potential to increase transit ridership. He concluded that current statistics regarding mass transit reveal transportation problems that can be addressed through comprehensive transportation demand management (TDM). Central to TDM is a public transit pass incentive program known as Unlimited Access. The discount bus pass program is shown to be an effective way of dealing with traffic congestion, parking shortages, and broader transportation issues.

Other relevant literature, including studies by Badamiand and Haider [8], Rye and Scotney [9], and Estupinan and Rodriguez [10], focused on how to improve bus service and enhance bus ridership base on case studies in Indian, Scottish, and South American cities. Their consensus is that public transport should satisfy the needs and motivations of different groups, along with improved operating conditions and policies to internalize costs of personal motor vehicle use, to address the challenge of providing financially viable and affordable public bus transit service.

As for our answer this question, inspired by previous studies and motivated by the empirical works of Li [11] and Lin [12], we pursue our multivariate analysis to identify the key factors affecting transit patronage based on a selected sample of 71 metropolitan areas. Table I shows the list of variables to be used for the multivariate analysis. Table II shows the descriptive statistics of our samples. Furthermore, by the diagnosis of the residuals we could recognize successful and unsuccessful examples for promoting transit ridership. For example, if the residual is positive, then it means that the transit patronage is higher than the predicted values. In other words, the city with the largest positive residual is regarded as the most successful example. Likewise, cities with negative residuals are referred as unsuccessful ones.

TABLE I
LIST OF VARIABLES TO BE USED FOR THE MULTIVARIATE ANALYSIS

Notation	Description	Unit
TPD	daily patronages of rapid transit systems	million
AUO	auto ownership(include car and scooter) per persons in the metropolitan area	numerical
COL	cost of living index in the metropolitan area, New York City as 100	numerical
Density	population density	thousand/km^2
GSP	gasoline price per liter in the metropolitan area	US$/liter
HW	median hourly wage	US$/hour
POP	population of the metropolitan area	million
P10	average transit fare for a 10-km trip	US$
Parking	daily parking rate in downtown garages	US$
SCT	scooter as a primary mode of commuting, 1 if the percentage exceeds 5%, 0 otherwise	1 or 0
TNRT	total number of stations for Light Rail Transit, and Mass Rapid Transit	numerical

Using TPD as the dependent variable, Table III shows the regression analysis with three models, i.e., the linear, the semi-log linear and the log-linear models. Obviously, from Table III we learned that the simple linear form is the best fitted regression model. We then pursue our regression by applying the linear forms to estimate three models for three groups, i.e., American and Australian cities, Asian and African cities, and European cities. Table IV shows the estimates of model parameters with various samples. In addition, we estimate the joint sample model and test the hypothesis whether separate models are better fitted to the data by F-test as shown in Equation (1). We find that the F-value, i.e., 3.476, exceeds the critical value at the 95% confidence level, which implies that separate models may be the better model specification for our sample.

TABLE II (A)
DESCRIPTIVE STATISTICS OF SAMPLE CITIES (AMERICA AND AUSTRALIA)

variable	minimum	maximum	mean	standard deviation
TNRT	12	468	82.13	91.494
P10	0.180	3.820	1.843	0.795
Pop	1.13	19.71	6.60	5.57
Density	0.128	139.491	8.448	28.367
AUO	0.081	0.765	0.606	0.236
Parking	8.970	44.100	22.233	10.740
COL	28.0	130.0	83.75	22.39
GSP	0.483	3.058	1.590	1.027
HW	11.389	23.776	17.746	2.720

TABLE II (B)
DESCRIPTIVE STATISTICS OF SAMPLE CITIES (ASIA AND AFRICA)

variable	minimum	maximum	mean	standard deviation
TNRT	21	348	105.59	88.860
P10	0.070	2.720	0.918	0.831
Pop	2.50	34.25	11.22	7.69
Density	0.739	496.757	69.266	159.055
AUO	0.010	1.080	0.298	0.330
Parking	1.280	52.500	18.466	14.133
COL	46.0	127.0	95.39	21.32
GSP	0.490	1.950	1.006	0.327
HW	3.815	23.730	15.272	5.545

TABLE II (C)
DESCRIPTIVE STATISTICS OF SAMPLE CITIES (EUROPE)

variable	minimum	maximum	mean	standard deviation
TNRT	10	380	89.20	88.977
P10	0.350	4.880	1.969	1.152
Pop	0.80	13.25	3.45	3.18
Density	0.085	38.462	6.880	9.217
AUO	0.067	0.588	0.407	0.151
Parking	8.000	70.770	30.572	17.071
COL	66.0	142.4	98.96	15.55
GSP	0.461	1.950	1.277	0.392
HW	10.660	57.444	25.717	9.985

With the information of Table III, we conclude that the key factors affecting transit patronage include TNRT, POP, COL, P10, Density, and GSP, by the order of parametric significance. It is consistent with our a priority that the number of rapid transit stations, population, daily parking rate, and gross domestic product have positive effects while auto and scooter ownerships, gasoline price, and transit fare have negative influence on transit patronage.

TABLE III
ESTIMATES OF MODEL PARAMETERS IN THREE FUNCTIONAL FORMS

Variable	Liner		Semi-log		Log liner	
	β	t	β	t	β	t
constant	-0.903	-1.499	5.097	6.293**	-5.793	-2.453**
TNRT	0.010	7.144**	0.008	4.283**	0.958	5.189**
P10	-0.370	-2.706**	-0.570	-3.097**	-0.848	-3.153**
Pop	0.094	4.395**	0.028	0.962	0.153	0.779
Density	-0.003	-2.644**	-0.002	-0.894	0.023	0.319
AUO	-0.248	-0.501	-1.529	-2.290**	-0.204	-1.163
SCT	-0.488	-1.877*	0.026	0.074	-0.224	-0.669
Parking	0.005	0.608	0.016	1.383	0.389	1.578
COL	0.023	4.011**	0.012	1.566	1.019	1.829*
GSP	-0.417	-2.605**	-0.076	-0.353	-0.007	-0.024
HW	-0.005	-0.391	0.025	1.450	0.697	1.878*
No. of Cities	71		71		71	
R^2	0.820		0.632		0.662	
Corrected R^2	0.790		0.570		0.605	
F-test	27.255		10.286		11.729	

*for one-tailed 95% significant level; **for one-tailed 99% significant level

TABLE IV (A)
ESTIMATES OF MODEL PARAMETERS IN LINEAR REGRESSION ANALYSIS (AMERICAN AND AUSTRASIA)

Variable	β estimate	Standard Error	t	p-value
constant	0.464	1.048	0.443	0.665
TNRT	0.007	0.004	1.813**	0.091
P10	-0.396	0.230	-1.719**	0.108
Pop	0.039	0.032	1.219	0.243
Density	0.005	0.013	0.381	0.709
AUO	-1.015	0.789	-1.287*	0.219
Parking	0.001	0.017	0.030	0.976
COL	0.006	0.006	0.950	0.358
GSP	-0.081	0.151	-0.538	0.599
HW	0.019	0.042	0.456	0.656
No. of Cities		24		
R^2		0.899		
Corrected R^2		0.835		
F-test		13.899		

TABLE IV (B)
ESTIMATES OF MODEL PARAMETERS IN LINEAR REGRESSION ANALYSIS (ASIA AND AFRICA)

Variable	β estimate	Standard Error	t	p-value
constant	-4.093	2.883	-1.420*	0.205
TNRT	0.013	0.004	3.216**	0.018
P10	-0.235	0.571	-0.412	0.695
Pop	0.089	0.031	2.874**	0.028
Density	0.000	0.002	-0.052	0.960
AUO	-1.678	1.474	-1.138	0.298
SCT	0.889	1.522	0.584	0.580
Parking	0.068	0.039	1.756**	0.130
COL	-0.001	0.014	-0.044	0.967
GSP	1.730	0.790	2.188**	0.071
HW	0.073	0.074	0.986	0.362
No. of Cities		17		
R^2		0.975		
Corrected R^2		0.933		
F-test		23.178		

Speaking for the positive effects, the most significant one is the number of rapid transit stations. Our interpretation for this is that more MRT stations make it easier to reach the destinations; therefore, cities with higher TNRT are easier to promote rapid transit. We also find out that population is the second most significant effect in the equation. And our interpretation is that bigger cities usually have more population with jammed traffic. As a result, it is very suitable for promoting transit usage. Therefore, it is no doubt that these two variables have both positive effects on the ridership of rapid transit.

TABLE IV (C)
ESTIMATES OF MODEL PARAMETERS IN LINEAR REGRESSION ANALYSIS (EUROPE)

Variable	β estimate	Standard Error	t	p-value
constant	-0.408	1.413	-0.288	0.776
TNRT	0.008	0.003	3.027**	0.007
P10	-0.266	0.186	-1.432	0.168
Pop	0.107	0.083	1.283	0.215
Density	-0.021	0.017	-1.231	0.233
AUO	0.809	1.531	0.528	0.603
SCT	-0.575	0.434	-1.323	0.202
Parking	0.005	0.011	0.481	0.636
COL	0.028	0.012	2.246**	0.037
GSP	-1.172	0.472	-2.481**	0.023
HW	-0.019	0.016	-1.178	0.254
No. of Cities		30		
R^2		0.828		
Corrected R^2		0.738		
F-test		9.152		

$$F = \frac{\left(e_*' e_* - \sum_{i=1}^{3} e_i' e_i \right) \Big/ 2k}{\sum_{i=1}^{3} e_i' e_i \Big/ \sum_{i=1}^{3} (n_i - k)} = 3.476 > F_{14,38,.01} = 2.61 \quad (1)$$

As for the negative effects, it is no surprise that auto and scooter ownerships will cut down the usage of public transit significantly. Due to the lack of sufficient data in scooter ownerships, we can only use the sum of cars and scooters ownership data. Therefore, it is important to collect each ownership data in the future study in order to evaluate the substitution effects of scooter with respect to transit.

Meanwhile, we find that the key factors affecting patronage also vary across different continents. For example, TNRT, P10 and AUO are the significant factors for American and Australian cities, while the list change to TNRT, POP, Parking, and GSP for Asian and African cities; and it becomes TNRT, COL, and GSP for European cities. Apparently, TNRT is the only significant variables at the 99% confidence level across various continents while POP is the other consistent and significant - approximately 95% of confidence level, variable in these models. And different coefficients in three models may reveal the variation of the effectiveness among global transit systems. For example, the European model has the highest coefficient on POP while the American model has the lowest one on the same variable. This implies that for cities with the same size, European cities attract more transit ridership than their counterpart in other continents. But, why is that? Our interpretation is that European cities are either richer or denser than most cities in the other part of the world. And these two features are very crucial for the development of rapid transit systems.

As for the individual model, we find that estimates of Density, Parking, COL and GSP are not significant as we expected. Likewise, we could not draw solid conclusion regarding the effects of Density, AUO or Parking on transit ridership in other models. The low t values might be the consequence of our limited data with little variation in the ranges of variables. For instance, the t values in Table V are mostly significant due to larger variation in variable ranges.

III. What Do The Successful Or Unsuccessful Cities Have In Common?

Based on the residuals derived from Table IV, we categorize our sample into two clusters. Table V lists the top three successful and unsuccessful cities from three sample groups. Surprisingly, most of the successful cities are not the well-known mega cities, except Mexico City. And the list of the unsuccessful also reveals the names of the big cities, such as Delhi and Shanghai.

TABLE V
DIAGNOSIS OF REGRESSION RESIDUALS: IDENTIFICATION OF SUCCESSFUL AND UNSUCCESSFUL CITIES

Group	American & Austrasia	Asia & Africa	Europe
Successful	Mexico City Santiago Sydney	Osaka Bangkok Guangzhou	Moscow Lisbon Prague
Unsuccessful	Buenos Aires Melbourne Chicago	Nagoya Delhi Shanghai Taipei Kaohsiung	Istanbul Madrid Oslo

IV. What Lessons Do We Learn?

From Table VI we learned that most of the successful cities satisfy the following Rule of Thumb:

If most of the interesting destinations are connected by transit network, and it is often the best way to get to these destinations by transit for most people, then the transit system of the city must be booming and flourishing.

In summary, if transit system is a very competitive mode of travel for urban activities, then its ridership is often higher than our expectation and the goal of promoting green and efficient urban transport could be easily achieved. However, it isn't easy to make transit faster and cheaper than other modes of urban transport. For instance, to increase the coverage area for transit services requires the investment of expanding existing transit network. Only a few cities such as Shanghai, Taipei and Beijing could afford to extend their network substantially in recent years. For cities which can't afford to build extensive transit network, then the alternative to reduce transfer time and to extend transit coverage is by providing more frequent bus services and more public bicycles for transfer. These actions are proven to be quite effective in cities such as Paris, Curitiba, Bogota, and other South American cities. To make transit cheaper, the simplest way is to offer subsidies to transit authorities to lower transit fares. And this approach is taken by most of the European cities. Likewise, most of the cities can't afford to pay huge subsidies to their transit systems. The alternative approach is to make driving to the downtown area more expensive by reducing the supply of parking facilities. This approach is very effective and it was widely applied to European, Japanese, Australian, and some American cities because the parking fees in downtown areas of these cities are quite expensive that make public transit more attractive for daily commuters and tourists.

V. Final Remarks

How to win passengers and influence motorists? For cities like Taipei and Shanghai, rapid transit becomes a symbol of fashionable life style and it turns out to be a very popular mode of urban transport. Therefore, to expand existing network to cope with the increasing demand is apparently the right thing to do. For cities like Kaohsiung where scooter remains the most popular mode of urban transport, it is important to carefully regulate the provision of parking spaces in downtown area and to introduce more cost-effective rapid transit systems, such as Light Rail or Bus Rapid Transit, to increase the coverage of transit services in order to draw motorists into the rapid transit systems.

In addition, because most of our estimated coefficients are insignificant due to limited ranges in variables, therefore, we suggest that it is necessary to include more cities for our future study to improve model reliability. Moreover, most of the cities are now devoted to promote the usage of green transport which also includes bus, bicycle and walk. In other words, it is essential to broaden our study to derive strategies to promote sustainable transport, not just rapid transit, for our cities. Consequently, our future study should collect data regarding daily commuting trips by other modes of green transport.

References

[1] Brian D. Taylor, Douglas Miller, Hiroyuki Iseki, Camille Fink, "Nature and/or nurture? Analyzing the determinants of transit ridership across US urbanized areas", in Transportation Research Part A: Policy and Practice, Volume 43, Issue 1, 2009, pp. 60-77.
[2] Graham Currie, Ian Wallis, "Effective ways to grow urban bus markets - a synthesis of evidence", in Journal of Transport Geography, Volume 16, Issue 6, Growing Public Transport Patronage, 2008, pp. 419-429.
[3] Graham Currie, John Rose," Growing patronage - Challenges and what has been found to work", in Transportation Economics, Volume 22, Issue 1, Reforms in Public Transport, 2008, pp. 5-11.
[4] David A. Hensher, "Sustainable public transport systems: Moving towards a value for money and network-based approach and away from blind commitment", in Transport Policy, Volume 14, Issue 1, 2007, pp. 98-102.
[5] S. L. Cullinane, "The relationship between car owner and public transport provision- a case study of Hong Kong", Transport Policy 9, 2002, pp. 29-39.
[6] Georges Bresson, Joyce Dargay, Jean-Loup Madre, Alain Pirotte," Economic and structural determinants of the demand for public transport: an analysis on a panel of French urban areas using shrinkage estimators", in Transportation Research Part A: Policy and Practice, Volume 38, Issue 4, May 2004, Pages 269-285.
[7] Bryan Dorsey, "Mass transit trends and the role of unlimited access in transportation demand management", in Journal of Transport Geography, Volume 13, Issue 3, September 2005, Pages 235-246.

[8] Madhav G. Badami, Murtaza Haider,” An analysis of public bus transit performance in Indian cities”, in Transportation Research Part A: Policy and Practice, Volume 41, Issue 10, December 2007, Pages 961-981.
[9] Tom Rye, David Scotney, ”The factors influencing future concessionary bus patronage in Scotland and their implications for elsewhere”, in Transport Policy, Volume 11, Issue 2, April 2004, Pages 133-140.
[10] Nicolas Estupinan, Daniel A. Rodriguez, ” The relationship between urban form and station boardings for Bogota’s BRT”, in Transportation Research Part A 42, 2008, Pages 296-306.
[11] Chia-Nung Li, Tsung-Yu Lai, “Transport and Land Use Relationship Defining Urban Form in Historical Context: A Comparative Analysis of 36 Global Cities”, in Journal of City and Planning, Volume 36, No. 1, 2009, Pages 25-49.
[12] Jen-Jia Lin, Ting-Yu Shin, “Built Environment Impacts of Transit-Oriented Development on Metro Ridership: An Empirical Study of Taipei Metro System”, in Transportation Planning Journal, Vo1. 36, No. 4, December 2007, Pages 451-476.

DATA SOURCE

[1] World metro bits: http://mic-ro.com/metro/index.html
[2] Geo Hive: http://www.geohive.com/
[3] City population: http://www.citypopulation.de
[4] World Gazetteer: http://www.world-gazetteer.com/wg.php
[5] Nation master: http://www.nationmaster.com/index.php
[6] Colliers: http://www.colliers.com/
[7] Mercer: http://www.mercer.com/home.htm
[8] Benzinpreis: http://www.benzinpreis.de/statistik.phtml
[9] 2010 Price water house Coopers: http://www.ukmediacentre.pwc.com/
[10] Pay Scale: http://www.payscale.com/rccountries.aspx
[11] Taipei Rapid Transit Corporation: http://www.tbkc.gov.tw/index.asp
[12] Kaohsiung Rapid Transit Company: http://www.krtco.com.tw/

TABLE I (A) STATISTICS OF SELECTED METROPOLITAN AREAS IN ALPHABETICAL ORDER - AMERICA AND AUSTRALIA

City	TNRT	P10	Pop	Density	AUO	SCT	Parking	COL	GSP	HW	TPC
Atlanta	39	1.75	3.5	0.161	0.765	0	12	76	0.483	17.63	0.093
Auckland	37	2.19	1.13	1.041	0.56	0	8.97	81	1.09	14.44	0.019
Boston	66	2	4.66	0.399	0.765	0	34	130	2.676	15.60	0.397
Brisbane	91	2.92	1.68	0.285	0.619	0	38.09	74	0.74	18.73	0.145
Buenos Aires	76	0.31	12	2.522	0.17	0	10	62.7	0.78	11.39	0.767
Chicago	151	2.07	8.65	14.272	0.765	0	31	113	2.772	18.37	0.542
Dallas	34	1.5	4.45	4.463	0.765	0	10.5	62	0.527	17.52	0.200
Houston	16	1.5	3.91	2.510	0.765	0	12	62	2.52	17.49	0.040
Los Angeles	30	2.5	13.83	3.201	0.765	0	28.2	87.5	3.058	19.56	0.123
Melbourne	119	2.7	3.37	0.383	0.619	0	30.47	94.2	1.5	17.92	0.005
Mexico City	175	0.18	18.1	2.305	0.138	0	15.5	97	0.56	13.54	4.000
Miami	22	2.17	4.92	0.310	0.765	0	17	82	2.825	14.62	0.052
Montreal	73	2.18	3.32	0.780	0.563	0	15.57	83	0.709	16.99	0.600
New York	468	2	19.71	139.491	0.765	0	44	100	2.905	20.55	4.449
Philadelphia	66	2	5.15	0.430	0.765	0	26	70	0.518	14.89	0.184
San Diego	54	1.6	2.67	2.773	0.765	0	26	28	0.616	19.28	0.048
San Francisco	43	1.5	5.32	0.583	0.765	0	25	116	3.033	20.20	0.274
San Paulo	58	0.99	18.7	2.354	0.081	0	15	97	0.526	23.78	1.874
Santiago	92	0.72	5.39	0.350	0.097	0	12	48	0.95	21.65	1.759
Seattle	12	1.5	2.71	0.128	0.765	0	28	94	2.858	18.77	0.400
Sydney	36	3.82	3.64	0.300	0.619	0	44.1	104.1	0.93	19.03	0.030
Toronto	74	2.18	5.67	0.796	0.563	0	20.61	88.1	1.263	18.57	0.762
Vancouver	49	2.1	2.03	0.705	0.563	0	15.57	85.8	1.44	18.68	0.203
Washington DC	90	1.85	3.93	22.203	0.765	0	14	74.6	2.886	16.70	0.589

TABLE I(B) STATISTICS OF SELECTED METROPOLITAN AREAS IN ALPHABETICAL ORDER – ASIA AND AFRICA

City	TNRT	P10	Pop	Density	AUO	SCT	Parking	COL	GSP	HW	TPC
Bangkok	44	0.84	8	1.031	0.296	1	11.43	75.1	0.87	9.87	0.564
Beijing	123	0.2	12.41	0.739	0.01	1	7.04	101.9	0.99	18.70	3.288
Cairo	55	0.18	16.25	75.935	0.03	1	21.576	94	0.49	8.26	1.918
Delhi	68	0.16	15.25	10.276	0.012	1	1.28	87.5	0.756	13.70	0.849
Guangzhou	62	0.59	11.46	1.256	0.01	1	1.9045	86	0.931	18.44	1.647
Hong Kong	95	1.19	6.89	6.241	0.076	0	28.38	117.6	1.95	14.97	3.586
Kaohsiung	37	1.06	2.5	0.849	1.08	1	22.46	69	0.95	15.49	0.114
Kolkata	21	0.07	13.22	481.392	0.012	1	2.59	116	0.948	6.22	0.274
Kuala Lumpur	60	0.48	5.1	20.988	0.641	1	21.151	46	0.53	18.18	0.299
Manila	42	0.24	19.15	496.757	0.031	1	2.65	73.4	0.91	3.82	0.948
Nagoya	93	2.62	9.18	28.121	0.543	0	32.934	107	1.26	16.90	1.170
Osaka	133	2.72	2.64	11.880	0.543	0	33.288	110	1.26	16.90	2.356
Seoul	348	0.71	9.66	15.967	0.307	1	12	117.7	1.094	23.73	5.611
Shanghai	163	0.44	14.24	2.024	0.01	1	11.74	98.3	0.885	14.97	3.074
Singapore	76	1.27	4	5.618	0.158	0	21.06	109.1	1.07	21.64	1.564
Taipei	85	0.78	6.5	2.796	0.759	1	29.946	86	0.95	15.49	1.233
Tokyo	290	2.05	34.25	15.661	0.543	0	52.5	127	1.26	22.34	8.696

TABLE I(C) STATISTICS OF SELECTED METROPOLITAN AREAS IN ALPHABETICAL ORDER - EUROPE

City	TNRT	P10	Pop	Density	AUO	SCT	Parking	COL	GSP	HW	TPC
Amsterdam	33	2.73	1.1	0.606	0.417	0	70.77	97	1.68	30.19	0.249
Athens	51	1.31	3.69	1.260	0.329	1	24.06	97	1.23	20.40	0.890
Barcelona	147	1.77	3.9	38.462	0.471	0	68.695	95.2	1.23	29.49	1.036
Berlin	195	2.75	3.68	4.126	0.508	0	25.48	93	1.901	36.53	1.225
Birmingham	23	2.52	2.28	8.515	0.426	0	13.928	85.4	1.44	13.45	0.014
Brussels	61	2	1.63	10.099	0.484	0	20.445	92.9	1.067	57.44	0.373
Budapest	42	1.25	2.1	3.999	0.262	0	29.5	87	1.27	13.38	0.814
Copenhagen	22	3.68	1.53	17.337	0.408	0	47.28	117.2	1.54	22.49	0.101
Hamburg	97	3.58	1.93	2.556	0.508	0	33.97	89.9	1.903	30.61	0.504
Helsinki	17	2.75	1.1	0.370	0.403	0	41.05	101.1	1.57	23.02	0.159
Istanbul	10	0.82	11.1	6.063	0.067	0	15.686	99.4	1.338	21.88	0.186
Kiev	46	0.35	2.5	2.980	0.098	0	8	91.7	0.655	28.96	1.759
Lisbon	52	1.05	2.25	0.761	0.537	0	16.98	66	1.61	27.49	0.493
London	268	3.6	8.28	4.851	0.426	0	56.68	125	1.607	18.70	3.279
Lyon	43	2.09	1.35	0.408	0.469	0	20.033	88.52	0.713	36.53	0.499
Madrid	281	1.31	4.9	0.466	0.471	1	35.39	96.7	1.95	29.08	1.879
Manchester	37	2.52	2.25	19.455	0.426	0	13.822	123	1.607	13.60	0.052
Milan	88	1.31	4.2	22.855	0.566	1	28.31	111.3	0.971	28.73	0.899
Moscow	177	0.65	13.25	12.257	0.124	0	25	142.4	0.616	16.96	7.049
Munich	100	3.01	1.68	5.412	0.508	0	28.31	93.1	0.994	43.08	0.956
Naples	30	1.33	3	25.582	0.566	1	16.354	76	0.987	21.77	0.079
Oslo	72	3.5	0.8	0.085	0.494	0	55.69	118.3	1.63	30.32	0.175
Paris	380	2.05	10.4	0.716	0.469	0	33.97	109.4	0.916	30.31	3.803
Prague	57	0.85	1.2	2.419	0.588	0	15.57	96	1.37	10.66	1.636
Rome	49	1.31	2.75	2.140	0.566	1	25.212	103.9	0.971	26.22	0.907
Saint Petersburg	63	0.604	4.59	7.574	0.124	0	31	103.1	0.461	22.05	2.279
Sofia	14	0.67	1.05	0.778	0.239	0	16.98	76.9	1.28	14.66	0.140
Stockholm	104	4.88	1.4	0.215	0.437	0	34.22	95.2	1.38	20.28	0.830
Vienna	96	2.22	1.55	3.735	0.558	0	56.62	102.3	1.37	35.82	1.364
Warsaw	21	0.61	2	0.328	0.261	0	8.14	95	1.05	17.41	0.312