Land Enhancement and Intensification Benefits of Investing in an Urban Rail Network

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ABSTRACT

Authorities around the world are looking for new approaches to justify the implementation of capital intensive transport infrastructure such as urban rail solutions. Traditionally, the benefits of an urban rail line include conventional user benefits such as savings in travel time, vehicle operating costs, accident costs and environmental costs, and more recently wider economic benefits. An alternative approach that is sometimes used is to consider the appreciation of property prices along a rail corridor, and the intensification of land development surrounding a rail station.

Using the development of new rail lines in Singapore as a case study, this paper will first apply the hedonic regression method to obtain estimates of elasticity between property price and transport accessibility. Secondly, using historical land use masterplans, the paper will discuss how the density of land use adjacent to rail stations has intensified over the past 15 years, through a comparative analysis of the land use density with respect to the distance to a rail station. Finally, with the North East Line as an example, the alternative approach comprising the land value enhancement of existing properties and the land intensification due to proximity to the line will be compared against the conventional user benefits.

1. Introduction

The Land Transport Authority (LTA) of Singapore adopts a project evaluation approach using cost benefit analysis to facilitate decision-making on the investment of transport projects. Economic evaluation requires estimating social benefits such as travel time savings, travel time reliability savings, crowding reductions, vehicle operating cost savings, and accident cost savings. These benefits are also known as conventional benefits.

In light of increasing cost projections, there is interest in alternative, but complementary, ways of measuring the benefits of transport projects, particularly in the case of the infrastructure-heavy urban rail network known as the Mass Rapid Transit (MRT). One approach being considered is to estimate land value enhancement, which represents a one-off increase in property values after the implementation of an MRT line. Concurrently, land intensification benefits, which represents the benefits of increasing land densities due to their proximity to MRT stations, can also be estimated and added on to land value enhancement.

In Section 2, we discuss the methodology for estimating the elasticity of property value enhancement with respect to transport accessibility, and the estimation of this benefit for an MRT line. In Section 3, we look into how the density of land use adjacent to MRT stations has intensified over the past 15 years by using historical land use masterplans produced by the Singapore government. Section 4 presents a comparison of the alternative benefits comprising land value enhancement and land intensification to the conventional user benefits, using the North East Line as a case study. Section 5 provides conclusions.

2. Land enhancement benefits

2.1 Methodology

The basic premise in real estate price studies is that property price is affected by both structural and locational characteristics. As a location becomes more attractive, because of certain characteristics such as an improvement in accessibility, demand for property in that location increases, resulting in higher prices. However, to the extent possible, it is also necessary to control for the different structural characteristics of properties such as property-type and tenure-type[1]. If undertaken successfully, the accessibility impact of the transport infrastructure can be isolated and the estimated elasticity parameter can then be a benchmark value applied to proposed future changes to the network to obtain estimates of future property value enhancements.

A simple way to assess the impact on property prices of changes in accessibility is using a before and after case study. However since there is limitation in obtaining the sales price data for the same property before and after the transport improvement, the before-and-after approach is not widely used in practice.

Rather, by comparing the values of many different properties across many different location settings within a region, it is possible to statistically estimate a series of coefficients that represent the incremental effect on property value associated with each individual characteristic of a building and its setting. Economists often refer to these regression estimates of property values as “hedonic price models” because they represent the implied prices that people place on obtaining desirable features in a property and avoiding undesirable ones. Hedonic regression is a revealed preference method of estimating the value placed on the attributes of certain assets. In this case we are looking at the relationship between residential property price data and structural and location attributes of the property.

With structural and location attributes, the regression analysis takes the following form, as in Equation (1):

$$\boldsymbol{Log\ (P_i) = \gamma_0 + \sum_m \gamma_m S_{im} + \sum_n \gamma_n L_{in} + \varepsilon_i} \qquad (1)$$

where:

P = Price per square metre

i = identifier for property *i*

S = Structural attribute of property

L = Location attribute of property

m = number of structural attributes

[1] Many residential properties in Singapore have lease tenures of 99 years and are generally less desirable than those of freehold properties.

n = number of location attributes
ε_i = error term
γ = coefficients

Among the location attributes considered for the hedonic analysis, special attention should be called to an Employment Accessibility (EA) factor which is designed to represent the accessibility of a property to employment. A lot of research into property price effects for public transport access use distance to the rail station as the location attribute of interest (see, for example, Mi et al. (2017) in the Singapore context). Under this approach, typically, only effects of proximity to an "average" station are estimated; stations-specific effects and their contribution to accessibility and connectivity of a network are ignored. For this reason, including the EA factor into the hedonic regression is preferred to a pure distance-to-station measure. The EA can be calculated for each property using transport model outputs and walking distance from property location to station. Each property sale in the database is assigned an EA depending on the sale date, and EA is calculated using Equation (2):

$$EA_i = \sum_j \frac{E_j}{E} e^{-\beta TTij} \qquad (2)$$

where:

- $\frac{E_j}{E}$ is the share of employment at Transport Zone *j* of the total employment *E* in Singapore.
- TT_{ij} is the transport cost incurred in terms of public travel time when travelling from property *i* to transport zone *j*. Each building in Singapore is identified using a postcode that is unique to that building.
- *β* is the decay parameter determining how households discount the value of employment at location j on travel time. A decay parameter of 0.057 has been used based on research undertaken in the UK for a similar study assessing the property price impacts of the Jubilee line and Docklands light rail extension (Ahlfeldt, 2011).

The EA factor is a number between 0 and 1 representing the accessibility from one property postcode to all other zones weighted by employment share at destination. EA is essentially the inverse of an exponential function of travel time to employment. The shorter the travel time the higher the EA. Figure 1 shows a relationship between EA and travel time.

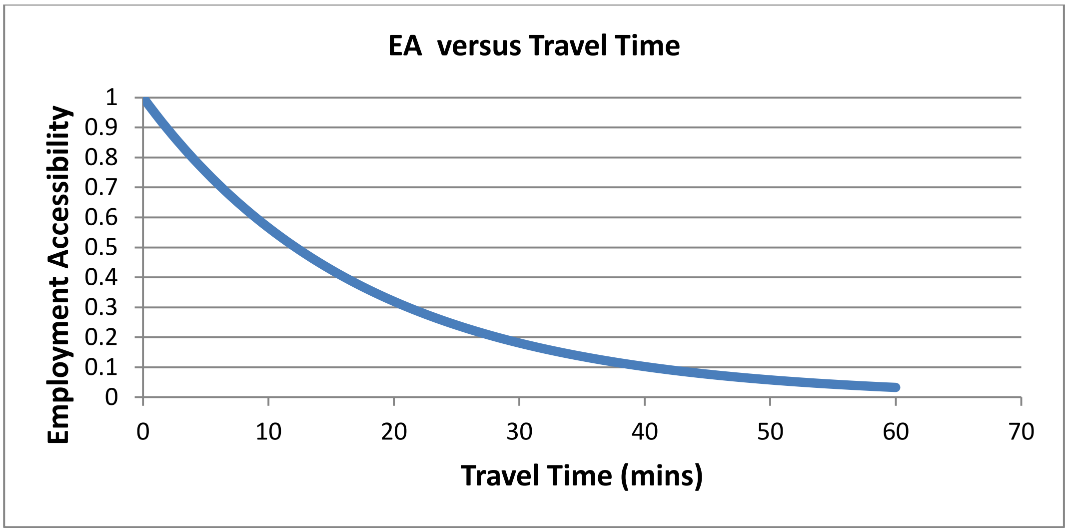

Figure 1: Relationship between employment accessibility and travel time

Using the employment accessibility factor means the result of the hedonic regression with log(prices) as the dependent variable will be a semi-elasticity factor (α) relating to a given change in employment accessibility by public transport to a percentage change in property prices. This can then be applied to future projects to estimate predicted net land value uplift. The regression equation therefore becomes:

$$\boldsymbol{Log\ (P_i) = \sum_m \gamma_m S_{im} + \sum_n \gamma_n L_{in} + \alpha \sum_j \frac{E_j}{E} e^{-\beta TTij} + \varepsilon_i} \quad (3)$$

Equation (3) was applied to property transaction databases with records from 1995 to 2014, with a discussion of results in the following Section 2.2. During this period, Singapore opened two MRT lines: the North East Line (NEL) in 2003 and the Circle Line in stages between 2009 and 2012.

2.2 Regression Results of Private Residential Data

The hedonic regression was performed for two residential data sets: private residential data and Housing Development Board (HDB) data[2]. For private residential data, the REALIS database from the Urban Redevelopment Authority (URA) was used. It contained 331,940 private residential transactions between January 1995 and December 2014. Almost all available variables in the database were included in the model. The main variables are described below.

Structural attributes include:

a) Size of property (m^2), with value ranging from $24m^2$ to $98{,}773m^2$ and an average of $128m^2$
b) Number of floors, with a maximum of 69 floors and an average of 9 floors
c) Whether purchaser previously owned a HDB flat or not.
d) Freehold or not.
e) Property type in terms of apartments, condominiums or other. 69% of private properties are condominium, 30% are apartment and the remainder are landed houses.
f) Prices were normalised to December 2014 levels using the monthly Singapore Real Estate Exchange Property Index (SPI)[3]

Unfortunately more detailed structural attributes of the property, such as number of bedrooms and bathrooms, were not available in the dataset. Year dummies, with 19 (0,1) variables covering 20 years of data were also included to control for the impact of cyclical economic factors on property prices.

The following location attributes were calculated from the postcode identifier of each property.

a) Distance to CBD attribute was calculated using the geodesic distance (straight line distance) between the postcode of the property and the Singapore City Hall, which has been used as the centre of the city. 407 entries had incomplete postcode identifiers and were removed from the database.

[2] HDB flats are public housing in Singapore. Over 80% of Singapore residents live in these.
[3] http://www.srx.com.sg/price-index

b) Distance to nearest MRT station with an average of 1,084m. This variable was only used to test alternative specifications to the EA factor. On average, there are about 58% of properties within 1000 metres of a MRT station and 42% outside this catchment.

c) The EA factor was calculated for each postcode for the 3 transport scenarios (Pre-NEL, Post-NEL and Pre-CCL, Post CCL). For each property transaction an EA was assigned depending on the postcode and date of sale.

d) Postal district that each property is a member of. There are 28 such postal districts in Singapore.

After cleaning the data, a total of 319,102 transaction records remained. Using the LTA strategic transport model, public transport travel time was estimated for three transport scenarios during the 1995-2014 period: (i) Pre-NEL, (ii) Post-NEL and Pre-CCL, and (iii) Post CCL. The zone to zone travel time matrix was converted to postcode to zone matrix by replacing walking time from a zone to a MRT station with walking time from a postcode to MRT station to improve travel time accuracy.

Employment data in 2008 was used for all locations and periods in the calculation of weighting EA so that changes in employment distribution over time did not impact EA.

The results for the regression analysis are shown in Annex A. Due to the large number of variables, the time and locational dummy variables have been omitted from the table. As can be observed from the t- statistics and p-values all variables are significant, except the strata. Given the property data base has limited structural information about the properties, an adjusted R square of 0.71 represents a very good fit. The R square is also comparable to Ahlfeldt’s (2011) UK study, where more structural data on properties such as number of bed rooms, number of bathrooms, central heating or not, garage, parking space, and details of property types were available. In the private property regression model for Singapore, the estimated α coefficient for EA is 1.088 and statistically significant at the 5% level.

Property price impacts for the North East line were then estimated by using the following formula in Equation (4) derived from Equation (3):

$$\boldsymbol{\Delta P/P = (e^{\alpha * (EA_2 - EA_1)} - 1)} \qquad (4)$$

A simulation was calculated for all postcodes in Singapore to calculate EA before and after NEL, and the percentage change in property price for all private properties can be estimated and shown in **Error! Reference source not found.**. Private property locations close to the new stations have estimated property price increases of 5 to 15%. As distance to station increases and the accessibility benefits of the MRT line reduces, so does the impact of accessibility on prices. The stations towards the end of the NEL, from Serangoon to Punggol, have a wider impact than those close to the city centre as the accessibility benefits to previously isolated areas are larger.

2.3 Regression results of HDB residential properties

Singapore HDB resale data was available for the period January 2000 to December 2014. The database contains address, property number and a concordance table with the postcode of each address. Unfortunately addresses were not in the same format and some data manipulation was required to match a significant number of the addresses in order to assign a postcode to each property. Of the 422,861 property transactions provided, 292,589 could be matched with a postcode and were used in the analysis. The average adjusted price per m^2 of HDB property is S$ 4,710 which is much lower than that of private property of S$15,292.

Structural variables used in the analysis were:

a) Size of property (area in m^2) with an average of $97m^2$, smaller than that of private property

b) Floor (or storey in integer) with an average of 7 floors

c) Apartment Type (1 room, 2 rooms, 3 rooms, 4 rooms, 5 rooms, Executive)

d) Age (integer) with an average of 19 years

Locational variables used were:

a) Distance to centre of the city (metres) (based on the straight line distance to City Hall)

b) Distance to MRT station. This variable is only used to test alternative specifications to EA. For HDB apartments, average distance to MRT (914m) is closer than that of a private property (1083m). Nearly two thirds (65.7%) of HDB properties compared to 58% of private properties are within 1 km of a MRT station

c) Postal District

d) EA was calculated by the same method as that for private residential property

The results for the regression analysis are shown in Annex B. Due to the large number of time and locational dummy variables these were omitted from the table.

The α coefficient for EA in the HDB regression is 2.546. This is more than double that for private residential property. This means that a HDB property owner in general would value MRT accessibility much more highly than a private property owner. This is reasonable since HDB property owners, with lower car ownership, are likely to rely more on MRT to provide accessibility than private property owners. This is illustrated in **Error! Reference source not found.** which shows that the percentage increase in HDB property prices is much higher than that in private property.

Private property HDB Property

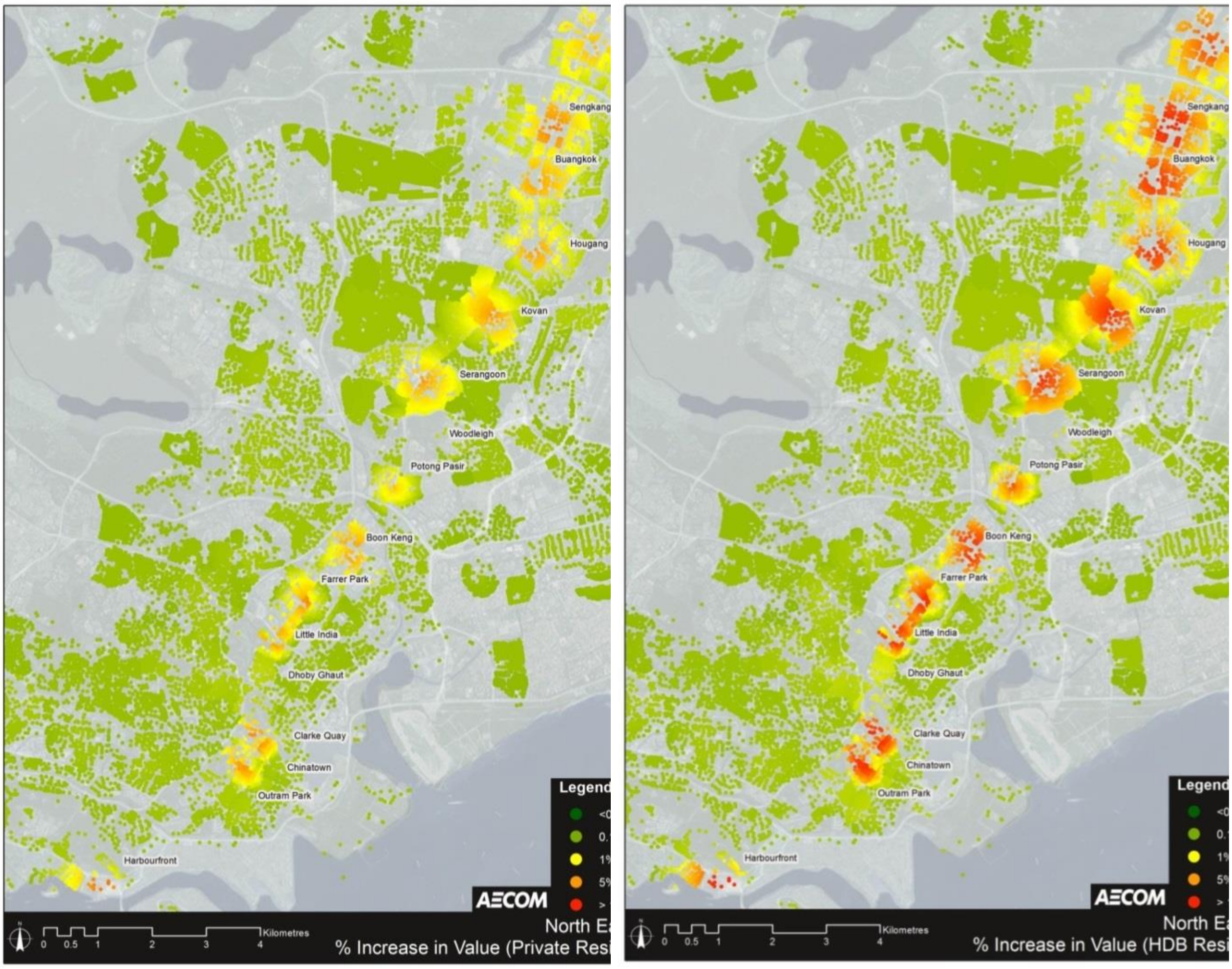

Figure 2 Estimated % increase in property prices from NEL
(Postcode data is available as points so areas close to stations with no coloured markers are due to gaps between postcodes)

2.4 Comparison to other results

The impact of public transport on property prices is difficult to compare across studies due to the different nature of the transport networks and the different methodologies used. Some results are shown in Table 1 and while not all are directly comparable they give some indication of the impacts found in other cities. The table shows that the UK study results (Ahlfeldt, 2011) are in the middle of the Singapore private and HDB residential property results.

Table 1: Comparison of other published studies

Study	Result
Singapore NEL & CCL	1% and 2.5% increase in private and HDB property prices respectively for every 1% increase in EA
1999 Jubilee Line and DLR Extension. London (Ahlfeldt, 2011)	2% increase in property prices for every 1% increase in EA
Atlanta Rapid Transit System (Nelson, 1998)	\$1.05 per feet distance to the station. Premium on property value in low-income areas; \$0.96 per feet distance to the station.
Washington D.C Metro Stations	Rent decreased by 2.4 to 2.6% for each one

Study	Result
(Benjamin and Sirmans, 1996)	tenth mile distance from the metro station
Bay Area Rapid Transit, San Francisco (Cervero , 1997)	10- 15% increase in rent for rental units within 1/4 mile of BART
Dallas Area Rapid Transit (Weinstein and Clower, 1999)	5.97% Increase in property value for properties within ¼ mile of the station
Portland Light Rail (Dueker and Bianco, 1999)	Property value declines $1593 for every 200 feet out of the station

2.5 Estimation of Land Value Enhancement for NEL

By using the regression equation and applying to a property before and after the implementation of an MRT line, and given all the structural and location attributes of the property remain unchanged and the only change being the accessibility, the land value uplift for a property can be estimated by applying Equation (5):

$$\Delta P = P_2 - P_1 = (e^{\alpha * (EA_2 - EA_1)} - 1)P_1 \qquad (5)$$

Where:

ΔP the change in property price per square metre

P_1 and P_2 the price per square metre of the property before and after the implementation of a MRT line

EA_1 and EA_2 the employment accessibility of the property before and after implementation of a MRT line

α the coefficient of EA

EA_1 and EA_2 were calculated for every postcode in Singapore based on public transport travel time before and after the implementation of a MRT line, weighted by employment. The estimated change of property price for one postcode is the product of (P_2-P_1) with the total gross floor area of residential property within the postcode. The impact of the MRT line on the whole of Singapore is the sum of all price changes of all postcodes in Singapore. Since the EA coefficient is different for private and HDB property, the calculation is also separate for private and HDB properties.

In the calculation of residential land value uplift, the following parameters were applied deriving from the property transaction databases.

a) Average dwelling floor area for HDB and private residential property: 97m^2 and 122m^2.

b) Adjusted average property price per square metre for HDB and private residential property in 2014: $4,710 and $15,331.

Table 2 below shows a summary of EA coefficients for the impact of NEL and CCL separately by partitioning the data into two subsets: before and after 2005 and conducting the regression separately. Interestingly, and especially for the HDB data, there appears to be a time dimension to the EA coefficient and the R^2 was improved when the full dataset was separated into two subsets. For the purpose of estimating the property value uplift for NEL, the EA coefficient used for residential private property was obtained from estimating the 1994-2005 dataset, and the coefficient used for HDB property was obtained from the 2000-2005 HDB dataset.

Table 2 Summary of EA coefficients for residential property

Residential property data source	Records	R^2	EA Coefficients
Private			
NEL (1994-2005)	118,585	0.61	1.093
CCL (2006-2014)	200,517	0.76	0.981
All years	319,102	0.71	1.088
HDB			
NEL (2000-2005)	142,535	0.61	2.138
CCL (2006-2014)	150,054	0.72	2.702
All years	292,589	0.54	2.546

The total residential property value uplift for NEL is shown in

Table **3**.

Table 3 Total residential property value uplift for NEL (in $Million)

Line (year)	Private property value uplift ($M)	HDB property value uplift ($M)	Residential property value uplift ($M)
NEL (2014)	1,198	2,833	4,031

It can be seen that for the NEL the land value uplift for HDB property is nearly three times that for private property. This is expected because the land surrounding the NEL corridor is dominated by HDB property. Figure 3 and Figure 4 show the estimated price increase in private residential property and HDB property respectively. The colours represent the total increase in property value in each postcode.

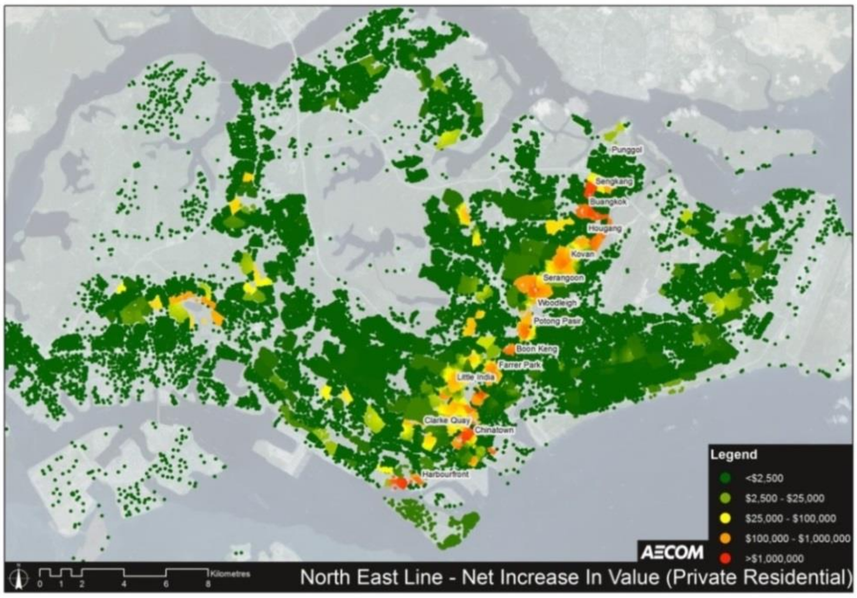

Figure 3 Estimated increase in private property prices from NEL

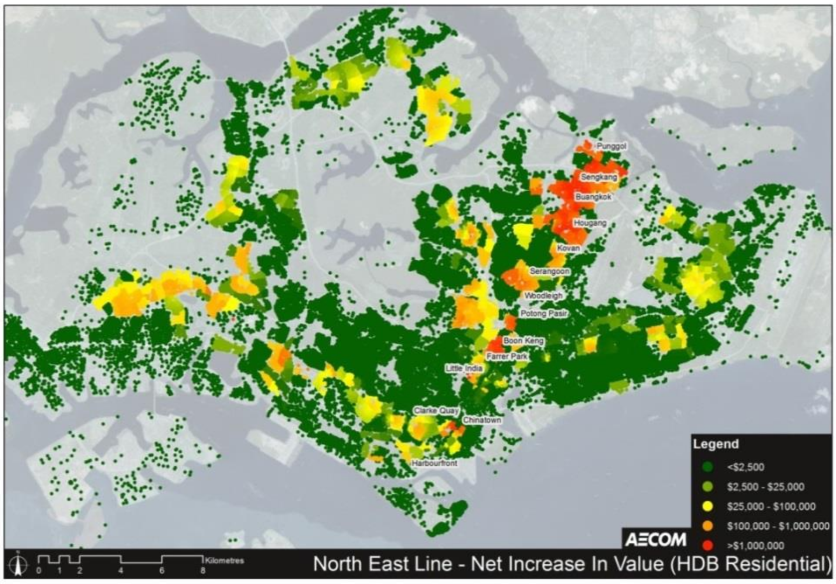

Figure 4 Estimated increase in HDB property prices from NEL

The above figures indicate firstly that the increase of HDB property value due to NEL is stronger than that of private properties as HDB owners are willing to pay more for accessibility and the NEL brings benefits to a large cluster of HDB dwellings in the north-east part of the country. Secondly, the impact of NEL on increasing property values, particularly for HDB property, is not restricted within NEL corridor, but also extends to other properties surrounding existing MRT lines although their level of increase is smaller. This is expected because with the opening of a new line, not only would the accessibility of properties within the NEL corridor be improved, but other properties located along the existing MRT lines would also enjoy an increase in accessibility due to the enhanced connectivity of the overall system.

3. Land Use Intensification

3.1 Introduction

Over the years in Singapore, property adjacent to MRT stations has been developed into much higher density than property further away from the station. This phenomenon has taken place due to market forces facilitated by land use planning. It can be said that transport infrastructure enables the intensification of land use along the transport corridor. By way of background, land planning in Singapore is undertaken by another government agency called the Urban Redevelopment Authority (URA), which releases a development Master Plan once every 5 years. The Master Plan represents the distribution of existing land use as well as the intention of future use for green field sites and areas to be rezoned. Hence, the Master Plan represents both market demand as well as the planning intention for the entire country.

The Master Plans prepared in 2003, 2008 and 2014 were analysed to determine the density of different land use types with respect to distance to MRT station. The impact of the MRT on land use intensification can then be determined by comparing the density of different land use types between land within and outside the MRT catchment.

There are five planning regions in Singapore: Central, East, North, North-East and West. Each region provides a mix of residential, commercial, business and recreational areas and supports a population of over 1,000,000 people. The regions are divided into a total of 55 smaller planning areas which have a population of about 100,000 each, served by a town centre and several smaller commercial/shopping centres. There are 32 land use types defined in the Master Plan which are grouped into six main categories. Table 4 shows the allocation of land by these categories over the past 12 years.

Table 4: Total land (m^2) by land use type and year

Land use	2003	2008	2014	2003-2008	2008 - 2014
Industrial	123,772,597	129,635,250	119,868,013	5%	-8%
Education and health	21,225,848	20,754,422	21,260,885	-2%	2%
Commercial	6,219,772	6,646,128	6,715,578	7%	1%
Residential	152,450,017	132,675,725	138,010,926	-13%	4%
Open space and park	118,151,745	119,027,164	122,783,698	1%	3%
Transport, utilities, reserve and others	353,000,669	367,882,040	373,336,446	4%	1%
Total land	774,820,647	776,620,728	781,975,546	0%	1%

Overall, the largest allocation of land is for transport, utilities, reserve and others. This is then followed by residential, industrial, open space and park, education and health, and commercial. This pattern is consistent over the three periods: 2003, 2008 and 2014.

3.2 Methodology for measurement of land use intensification

The measurement of land use intensification is conducted by analysing the Master Plans through several steps using GIS, as follows:

a) Determine the average gross plot ratio (GPR) with respect to distance to the MRT station for four main land use types: industrial, education & health, commercial, and residential, over the three Master Plan periods. The GPR refers to the ratio of the Gross Floor Area to site area (or surface area), and is considered as a measure if the density of development of the site.

b) Determine the change in GPR by comparing the GPR for land within MRT catchments (radius <800m), with the GPR of land outside the catchment (radius >800m). 800m is considered to be a reasonable distance where people are willing to walk to a station, and hence is adopted as a reasonable distance of influence of MRT.

c) Create buffer zones around stations of NEL, CCL and future committed rail lines to form three sub-catchment areas: within 200m, between 200 and 400m, and between 400 and 800m. Each buffer is adjusted to not include the catchment of existing stations. For example, the buffer for NEL stations would exclude the catchment of the stations interchanged with the existing NS & EW lines such as Dhoby Ghaut and Outram Park stations (see Figure 5).

d) Calculate land parcel by land use type for each station buffer. A land parcel is included if its centre point is within the buffer area

e) Calculate the land intensification benefit for a station as equal to the land parcel area (within a sub-catchment) multiplied by the net change in GPR (by sub-catchment) and multiplied by land value ($/$m^2$) for each land use type. The formula is expressed as below:

Land intensification benefit ($) = parcel area (m²) x GPR net change x land value ($/m²)

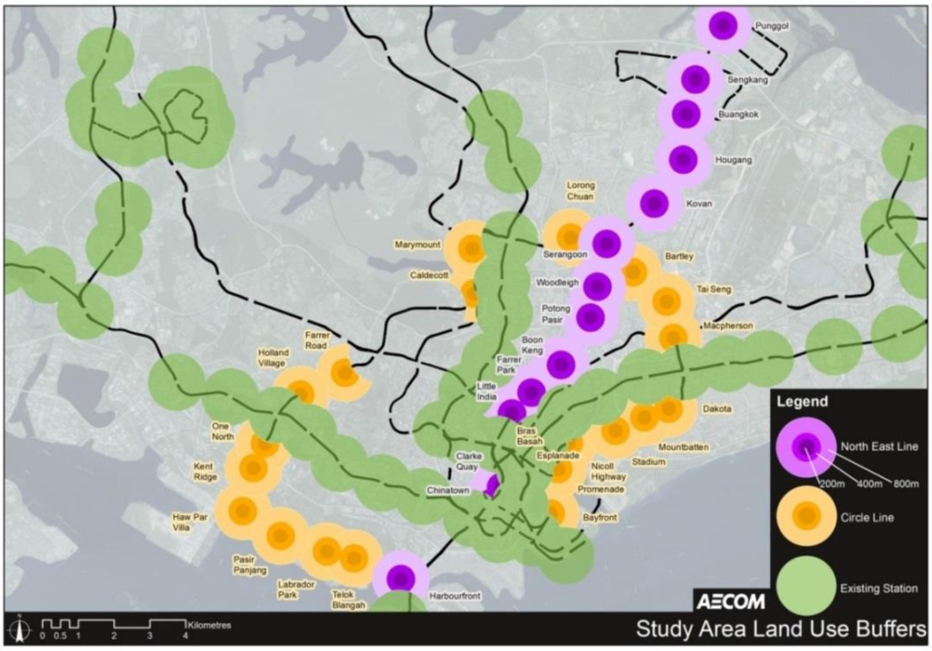

Figure 5: Land use buffers for NEL and CCL for land intensification calculation

3.2.1 Analysis of average plot ratios

The level of land intensification around MRT stations can be estimated by looking into the change of GPR for each main land use type with respect to distance from the MRT station. Table 5 shows the average GPR over the three Master Plans for four land use types: industrial, education and health, commercial, and residential, and by region and distance to the MRT station. The average GFRs with respect to distance to the MRT station (<800m) were based on the base network (i.e. without NEL and CCL). The GPR with respect to distance to the MRT station (>800m) were also calculated for each region but excluded all existing and future station catchments.

Table 5: Average GPR by land use and by distance to MRT station

Region	Dist. to MRT	Average GPR			
		Industrial	Education & Health	Commercial	Residential
WHOLE ISLAND	<200m	1.86	4.20	4.11	2.98
	200m - 400m	1.80	-	3.44	2.40
	400m - 800m	1.91	3.33	3.39	2.21
	>800m	2.02	1.76	2.48	1.77
CENTRAL AREA	<200m	-	-	4.59	3.11
	200m - 400m	-	-	4.33	2.84
	400m - 800m	-	4.20	4.23	2.91
	>800m	2.35	2.75	2.59	2.19
WEST REGION	<200m	1.43	-	4.56	2.97
	200m - 400m	1.41	-	4.43	2.89
	400m - 800m	1.61	-	4.96	2.69

Region	Dist. to MRT	Average GPR			
		Industrial	Education & Health	Commercial	Residential
	>800m	1.84	1.78	1.65	1.86
EAST REGION	<200m	2.50	-	4.00	2.39
	200m - 400m	2.41	-	3.67	1.62
	400m - 800m	2.17	-	-	1.54
	>800m	2.11	1.72	1.70	1.84
NORTH REGION	<200m	-	-	3.70	2.88
	200m - 400m	-	-	3.50	2.82
	400m - 800m	2.39	3.00	3.50	2.75
	>800m	2.28	1.87	1.25	2.24
NORTH-EAST REGION	<200m	-	-	2.83	3.63
	200m - 400m	2.50	-	-	2.91
	400m - 800m	2.50	-	-	2.85
	>800m	2.03	1.40	1.59	1.72
CENTRAL REGION (exclude CA)	<200m	2.50	4.20	3.59	3.27
	200m - 400m	2.55	-	3.05	2.70
	400m - 800m	2.54	2.80	3.03	2.33
	>800m	2.18	2.15	2.64	1.70

Generally it can be seen that the GPR for a land use is highest near to MRT stations and lower further away. For example, looking at the residential land use for the whole island, the GPR for land within 200m of MRT stations (2.98) is higher than that for land within 200-400m (2.40), which is in turn higher than 400-800m (2.21), and then higher than 800m (1.77). The pattern is similar for commercial land and other land uses. For industrial land, the GPR for developments within 800m are higher than those outside 800m for most regions, although the relative difference of GPR between <800m segments does vary. Therefore it can be said that the presence of an MRT station will increase the GPR or the density of land use development. The benefits of land intensification of an MRT station are calculated as the net increase of GPR (i.e. the difference between the GPR of land (e.g. within 200m) and the GPR of land outside the MRT catchment (i.e. distance to MRT >800m)), multiplied by the size of the relevant land parcels (within a sub-catchment for each land use), and by an average unit value ($/m^2) for each land use type.

3.2.2 Average land price

In order to convert the land use intensification into monetary form, the average land values indexed to the last quarter of 2014 by land use type and by postal district derived from property sale transactions as presented in the previous chapter were used. Table 6 shows the average 2014 indexed land price by land use. Since there is no transaction price data for education and health, the unit land price of commercial was adopted for this land use.

Table 6: Average 2014 indexed land price ($/m^2) by land use

Residential - Private	Residential - HBD	Commercial	Industrial
15,217	5,233	21,918	6,249

3.2.3 Land parcels

The land intensification for NEL requires calculations of the land parcels by land use type and by sub-catchment (i.e. 200m, 400m and 800m). Table 7 shows the aggregation of all sub-catchments of land parcels by land use type and by station.

Table 7: Total land parcels (m^2) within 800m catchment of NEL stations

Station	Postal District	Region	Residential	Commercial	Health/Edu	Industrial	Total
Kovan	10	North-East Region	1,325,855	-	46,054	-	1,371,908
Sengkang	13	North-East Region	631,038	17,465	170,747	-	819,250
Farrer Park	2	Central Region	548,381	161,098	61,893	-	771,372
Harbourfront	1	Central Region	195,595	194,651	-	14,331	404,577
Potong Pasir	7	Central Region	848,721	-	264,319	193,304	1,306,343
Woodleigh	7	Central Region	386,000	-	19,083	-	405,082
Hougang	10	North-East Region	1,059,273	29,452	174,341	-	1,263,067
Little India	2	Central Region	7,936	11,901	-	-	19,837
Serangoon	10	North-East Region	1,268,771	19,983	152,662	-	1,441,416
Boon Keng	3	Central Region	863,117	23,258	105,552	125,765	1,117,693
Chinatown	3	Central Region	72,032	80,838	-	-	152,870
Punggol	19	North-East Region	948,780	-	116,110	-	1,064,890
Buangkok	13	North-East Region	1,500,127	-	120,839	163,586	1,784,552
Total			9,655,626	538,645	1,231,599	496,986	11,922,856

3.3 Land intensification benefit calculations

The land intensification benefit in dollars for a station on the NEL are summarised by station and postal district as shown in Table 8.

Table 8: Total land use intensification value ($mil) for NEL stations

Station	Postal District	Region	Residential	Commercial	Health/Edu	Industrial	Total
Kovan	10	North-East Region	15,240	-	-	-	15,240
Sengkang	13	North-East Region	4,794	432	-	-	5,226
Farrer Park	2	Central Region	4,956	1,955	641	-	7,552
Harbourfront	1	Central Region	1,361	3,379	-	37	4,776
Potong Pasir	7	Central Region	6,310	-	2,287	495	9,092
Woodleigh	7	Central Region	2,286	-	49	-	2,336
Hougang	10	North-East Region	11,925	560	-	-	12,485
Little India	2	Central Region	79	198	-	-	277
Serangoon	10	North-East Region	13,641	627	-	-	14,268
Boon Keng	3	Central Region	5,922	259	1,300	387	7,868
Chinatown	3	Central Region	429	867	-	-	1,296
Punggol	19	North-East Region	6,680	-	-	-	6,680
Buangkok	13	North-East Region	11,799	-	-	581	12,379
Total			85,422	8,277	4,276	1,500	99,475

Overall the table above indicates that the NEL could bring about a total land intensification benefit of $99,475 million compared to the case without NEL. This land use intensification is regarded as an additional benefit to the initial property value uplift based on existing land use. For the NEL, much of the developments around its stations seem to have already taken place. Nevertheless, assuming that the land intensification happens gradually over 60 years and allowing a discount rate of 4%, the net present value of this intensification benefit (in 2014) is estimated at $37,508 million.

4. Comparison of results between approaches

4.1 Conventional approach

The total benefits by the conventional approach for NEL were estimated and summarised in Table 9 below.

Table 9: Total benefits for NEL by conventional approach

Components	2015 PV of benefits ($ mil.)
Public transport time savings	26,674
Private vehicle highway time savings	5,263
Vehicle operating cost savings	4,768
Accident cost savings	1,523
Bus operating cost savings	493
Total present value of benefits	38,720

4.2 Alternative approach

Table 10 shows the present value of property value uplift and intensification benefits for the NEL. The property value uplift represents a one-off property value enhancement of existing properties due to the improvement in accessibility resulting from the implementation of an MRT line. The land use intensification benefits represent the additional property development that can occur due to the proximity to a MRT station. Therefore these are mutually exclusive benefits that can be added together to represent the total benefits of building MRT lines without double counting.

Table 10: Present value of property value uplift and intensification benefits

Type of benefits	2014 PV of benefits ($M)			
	Residential	Commercial	Industrial	Total
Land Uplift	4,031	8,518	247	12,796
Land Intensification	32,209	4,733	566	37,508
Total	36,240	13,251	813	50,304

4.3 Comparison between two approaches

The benefits estimated by the alternative approach are about 30% higher than those calculated by the conventional method. The difference is partly due to the conventional benefit totals not yet incorporating Wider Economic Benefits. However, even when these have been included, one additional factor that could cause the estimates derived by the alternative approach to differ from conventionally calculated transport benefits and WEBs is the discount rate. Conventional benefits are estimated for each future year and then discounted to a present value using a public sector discount rate. Property market values which are the basis for the alternative approach are a capitalisation of future benefits in property prices and hence are equivalent to a present value. However, this present value does not necessarily reflect the same discount rate as used for the conventional benefits calculation. Rather, it will be the average of the discount rates (or rate of time preference) of all the individual property purchasers. Depending on how the public sector rate is derived and how recently it has been reviewed, these individual discount rates may be less than the public sector rate particularly when global interest rates have been trending lower. For example, if the discount rate used to calculate the present value of conventional benefits was assumed to be 3% in real terms, instead of 4%, conventional benefits would be much closer to the benefits derived by the alternative approach.

5. Conclusions

Total benefits estimated by the alternative approach for NEL are approximately 30% higher than those calculated with the conventional method. The reasons for this may include:

a) The benefits calculated by the conventional method not yet including Wider Economic Benefits;
b) Benefits of trips being made in less crowded or congested conditions as a result of the project are not fully valued; and
c) Property values, which are the basis of the alternative approach, may imply a lower discount rate for conventional benefits than the government discount rate of 4% that has been used.

The estimates of property value enhancement and land use intensification benefits provide an alternative measure of some of the benefits of the MRT projects and a different way of describing and demonstrating the validity of these benefits. These benefits are not additional to the conventional transport benefits and should not be simply included in conventional benefit/cost ratios. However, the alternative approach can be useful in cross-checking the validity of the conventional approach and may provide a scale of the benefits not yet captured if the discrepancy between the alternative and conventional approach is large.

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Appendix

A1 - Regression results for private residential properties

R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
			R Square Change	F Change	df1	df2	Sig. F Change
0.705	0.705	0.20346	0.705	12918.997	59	319042	0.000

Main Independent Variables	Unstandardized Coefficients		t-value	p-value
	B	Std. Error		
(Constant)	9.309	0.059	157.626	0.000
Floor	0.006	0.000	108.451	0.000
Area_sqm	-2.583E-06	0.000	-3.044	0.002
Freehold	0.150	0.001	160.033	0.000
EA	1.088	0.019	56.514	0.000
HDB purchaser	-0.018	0.001	-22.033	0.000
Strata	0.031	0.059	0.534	0.593
Resale	-0.252	0.001	-314.766	0.000
Sub_sale	-0.036	0.001	-28.150	0.000
Dist to city	-3.255E-05	0.000	-120.448	0.000
Apartment	0.202	0.004	56.242	0.000
Condo	0.282	0.003	80.678	0.000
Quarter1	-0.028	0.001	-25.092	0.000
Quarter2	-0.027	0.001	-25.980	0.000
Quarter3	-0.012	0.001	-11.629	0.000

A2 - Regression results for HDB properties

R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
			R Square Change	F Change	df1	df2	Sig. F Change
.540	.540	.11630414	.540	7008.430	49	292538	0.000

Main Independent Variables	Unstandardized Coefficients		t-value	p-value
	B	Std. Error		
(Constant)	8.889	0.005	1744.639	0.000
Area_sqm	-0.002	0.000	-71.495	0.000
EA	2.546	0.016	162.630	0.000
Dist_to_cbd	-1.808E-05	0.000	-96.161	0.000
Age	-0.007	0.000	-182.300	0.000
Floor	0.007	0.000	140.598	0.000
Executive	0.093	0.001	78.872	0.000
room1	-0.439	0.007	-66.223	0.000
room2	-0.210	0.003	-63.505	0.000
room3	-0.121	0.002	-71.319	0.000
room4	-0.076	0.001	-81.615	0.000
Quater1	0.004	0.001	7.003	0.000
Quater2	0.003	0.001	4.819	0.000
Quater3	-0.002	0.001	-3.023	0.003