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Land use and transport interaction modelling using a simplified Spatial General Equilibrium (SGE) model: Case study on Cross River Rail, Brisbane

Stuart Donovan[1,2], James Ramsey[1], Daniel Veryard[1,]
Venuri Jayatillaka[1,] Nancye Ng[1,] and Heshan Samaratunge[1]
[1] Veitch Lister Consulting Ltd
[2] Vrije Universiteit Amsterdam
Email for correspondence: stuart.donovan@veitchlister.com

1. Introduction

A surge in recent research since 2010 onwards has expanded our understanding of the interaction between transport and land use outcomes. Much of this research has combined spatial equilibrium concepts with discrete choice random utility models (Ahlfeldt et al., 2015; Allen and Arkolakis, 2014).[1] More recent research considers the implications of these models for welfare and finds substantial differences between scenarios where land use is fixed versus when it can change (Severen, 2021, Tsivanidis, 2021). In this paper, we first introduce a simplified spatial general equilibrium (SGE) land use model in the spirit of Ahlfeld et al. (2015), which we link to a strategic transport model. Second, we outline our additions to this model which include the adding the effects of non-work transport costs on location choice (in addition to commuting costs), and an approach to the measurement of model convergence. Third, we consider the economic appraisal of transport projects in the presence of land use change. Fourth, we apply the model to a recent transport project (Cross River Rail) in Brisbane, Australia. Here, allowing for land use change leads to a 30-40% increase in conventional economic benefits. On this basis, we conclude that quantitative spatial models have important implications for our transport policies.

2. Methodology

Various methods exist for modelling the interaction between land use and transport, such as 'LUTI' and SGE models. Here, we adopt a SGE model—hereafter referred to as "the land use model"—developed by Veitch Lister Consulting (VLC).[2]

2.1 Model steps and assumptions

The land use model is a simplified version of the model described in Ahlfeldt et al (2015), which assumes:

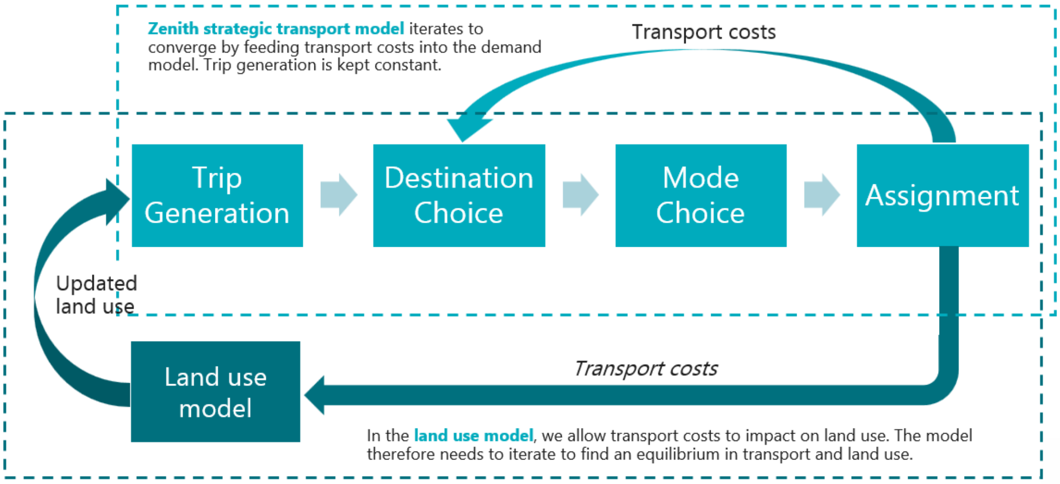
- Transport costs affect the relative attractiveness of locations within the city to commuters, that is, as places to both live and work

[1] The term "quantitative spatial models", or QSM, is sometimes use to describe these models.
[2] This model is also referred to as *Spatial,* see: https://veitchlister.com/our-solutions/spatial/

- The study area is a “closed city”, such that there is no inward or outward migration and the total number of people / jobs is fixed between the base and project scenarios.

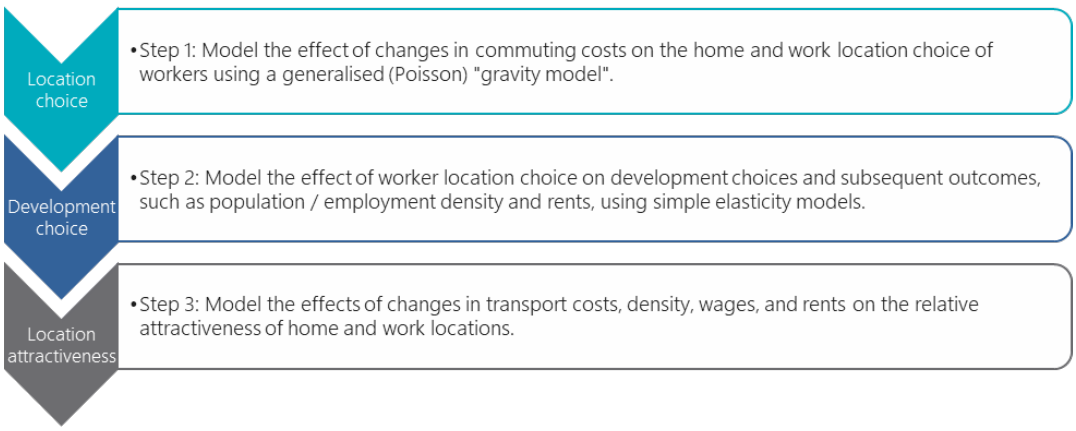
We link the this model to VLC’s "Zenith" strategic transport model, which represents the two-way relationships between transport demand and network performance over a defined geography. [3] By running the land use and transport models together, transport costs are determined endogenously as a function of the distribution of people and jobs over locations—in this case, SA2s that are mapped to travel zones. We automate the link between the models, such that information passes iteratively between them until changes in transport costs and land use inputs (updates to population and employment in each zone) stabilise across both parts of the system (see Figure 1).

Figure 1: Land use and transport modelling interaction approach



Put simply, we seek to identify a joint equilibrium in both the transport and the land use models. From an economic perspective, convergence in the land use model denotes a “spatial general equilibrium”. That is, an allocation of people and jobs where—conditional on transport costs—no worker can make themselves better off by changing their location. The land use model itself consists of three core elements (see Figure 2).

Figure 2: Core elements of the land use model



First, it models the effect of changes in commuting costs on the home and work location choice of commuters. We extend the model in Ahlfeldt et al (2015) to allow for differences between

[3] For more information on VLC’s Zenith model, refer to: https://veitchlister.com/our-solutions/zenith/

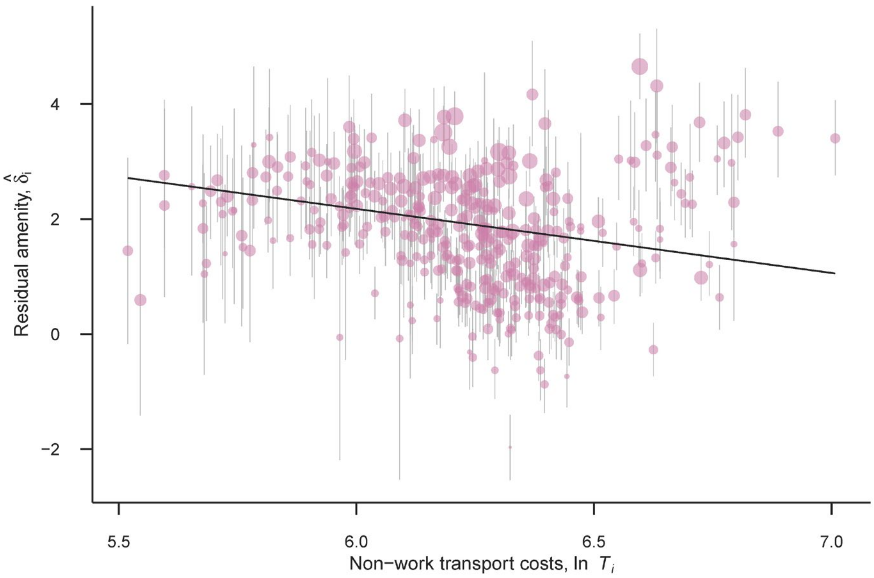
white- and blue-collar workers, giving rise to heterogenous effects across these populations. Second, it models the effect of worker location choice on housing markets, specifically the effects of changes in population and employment density on rents. Finally, it models the combined effects of changes in non-commuting transport costs, density, wages, and rents (both residential and commercial) on the attractiveness of locations. The model then loops back through this three-step process until convergence. That is, the equilibrium land use outcome that results from the project or policy that is being modelled.

Like all models, this approach represents an abstract simplification of a complex real-world system. Nonetheless, SGE models have been found to offer several advantages over other land use model approaches in terms of their ability to produce logical and intuitive results, the robustness of their microeconomic foundations, their efficient model run times, and the portability of models / parameters.

2.2 Allowing for the effects of non-work transport costs on location choice

In Ahlfeldt et al. (2015), location choice is affected only by commuting costs. Changes in non-work transport costs such as those for education and retail trips do not affect location choice in Ahlfeldt's model. Notwithstanding their importance for residential location choice (see Section 4.1 on discussion of importance of commuting trips for residential location choice) commuting trips represent only a portion of household trips. The 2018 Household Travel Survey in SEQ, for example, finds "work" trips make up only around 28% of all trips. For this reason, we extend the Ahlfeldt model to allow for non-work transport costs to affect location choice such that the residential amenity attached to home locations is a function of non-work transport costs, $\ln T_i$. We estimate residential amenity, $\hat{\delta}_i$, per Ahlfeldt et al. (2015)[4] and source estimates of average generalised costs for non-work travel, $\ln T_i$, from *Zenith*. Figure 3 plots $\hat{\delta}_i$ versus $\ln T_i$.[5]

Figure 3: Residual amenity $\hat{\delta}_i$ (vertical axis) versus non-work transport costs $\ln T_i$ (horizontal axis).



[4] Residential amenity is a function of the density of residents and jobs (increasing density = more amenities, e.g., public parks, schools, services etc.)

[5] The residual amenity $\hat{\delta}_i = \delta_i + \varepsilon(1-\beta)\ln r_i = \delta_i + \varepsilon(1-\beta)^2 \ln w_i$, where $\ln w_i$ denotes average income from the 2016 census, $\ln r_i$ = natural log of residential rents, and $\varepsilon = 3.79$ and $1-\beta = 0.23$ are parameters, which we estimate separately.

Notes to Figure 3: The size of points denotes the number of workers that reside in each location and the grey bars denote the 95% confidence interval of the estimate of $\hat{\boldsymbol{\delta}}_{\boldsymbol{\iota}}$. The estimated elasticity is -0.79 (s.e. 0.23).

We observe a subtle but expected negative trend, with an estimated elasticity of -0.79 (s.e. 0.23) in our preferred model. This finding indicates that increased accessibility to non-work locations (i.e. lower non-work transport cost) leads to higher amenity. Testing finds this has significant implications for location choice that tend to reinforce changes in commuting costs.

2.3 Convergence in land use and transport models

Convergence is the term to describe an equilibrium in a model system, in this case a joint equilibrium between the land use and transport models. From an economic perspective, convergence in the land use model denotes a "spatial general equilibrium". That is, an allocation of people and jobs where—conditional on transport costs—no worker can make themselves better off by changing their location. Neither ATAP (2022) nor the UK DfT's Transport Modelling Appraisal Guidance provide advice on convergence in linked land use and transport models. In lieu of formal guidance, we seek at least the same minimum level of convergence advised in UK DfT (2020) for demand/supply gap in strategic transport models (i.e., 0.1%). This gap is calculated using the updated values for transport costs (generalised travel time) and land use inputs (in this case total population and total employment) between iterations. We find it helpful to relate these values to transport cost and land use totals in the starting (base case) iteration using the following formula:

$$Gap_n^k = \frac{\sum_{ij}|k_n - k_b| - \sum_{ij}|k_{n-1} - k_b|}{\sum_{ij} k_b} \tag{1}$$

Where Gap_n^k denotes a standardized measure of convergence for criteria k on iteration n; k_n and k_b denote the metric of interest (e.g., transport costs or land use variable) on iteration n and in the Base, respectively; and ij refers to all zone-to-zone pairs. Differences are calculated as absolute differences. In testing, we found the speed of convergence of the linked land use and transport system was improved by averaging, or "blending", the change in generalized costs between the current and previous iteration prior to updating the land use outcomes.

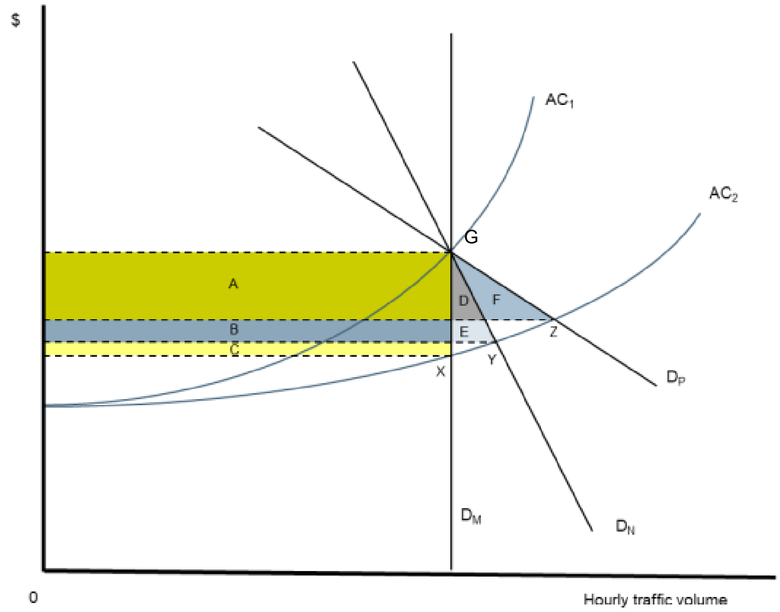
2.4 Economic appraisal approach

We use the method from ATAP – O8 (2021) to appraise the monetisable economic benefits of the case study. This method estimates user benefits using the standard consumer surplus approach, comparing the project case scenario with dynamic land use against the base case scenario. The difference in benefits between the dynamic (project case) and static (base case) scenarios is assumed to represent benefits due to land use change.

This method assumes that, for all origin-destination-mode combinations, travel demand is unchanged between land use scenarios unless the transport costs change. In other words, travel demand can change in response to land-use-only change, but the gross utility of the traveller still does not change in response to home or work relocation (i.e. the demand curve swivels, or rotates around a point, but does not shift inwards or outwards in a more general sense). Figure 4 illustrates this setting (x here is equal to quantity of trips described as hourly traffic flow, and y = cost / price), where the dynamic land use demand curve Dp has a different slope to static land use demand curve Dn, but still assumes that Dp must pass through point G in applying the rule of half in calculating user benefits (shaded areas D, E, F), not allowing a vertical or horizontal shift of the demand curve.

This assumption is convenient, in that it allows us to apply conventional methods of economic appraisal. We suggest, however, it is only a valid approximation of the consumer surplus under specific conditions, where the only relevant factor in the household utility function with respect to location choice is generalised travel costs. In practice, housing costs and a host of other factors may affect the amenity of locations and give rise to shifts in the demand curve that are not directly related to changes in generalised travel costs, including rents / land prices and a location's amenity – both of which will be endogenously determined with the number or density of households (and jobs) located in an area. Such situations will mean the demand curve does not always pass through point G. Notwithstanding these limitations we have implemented this approach for the economic appraisal of this specific case study.

Figure 4: User benefit calculation with dynamic land use change (source ATAP – O8, 2021)

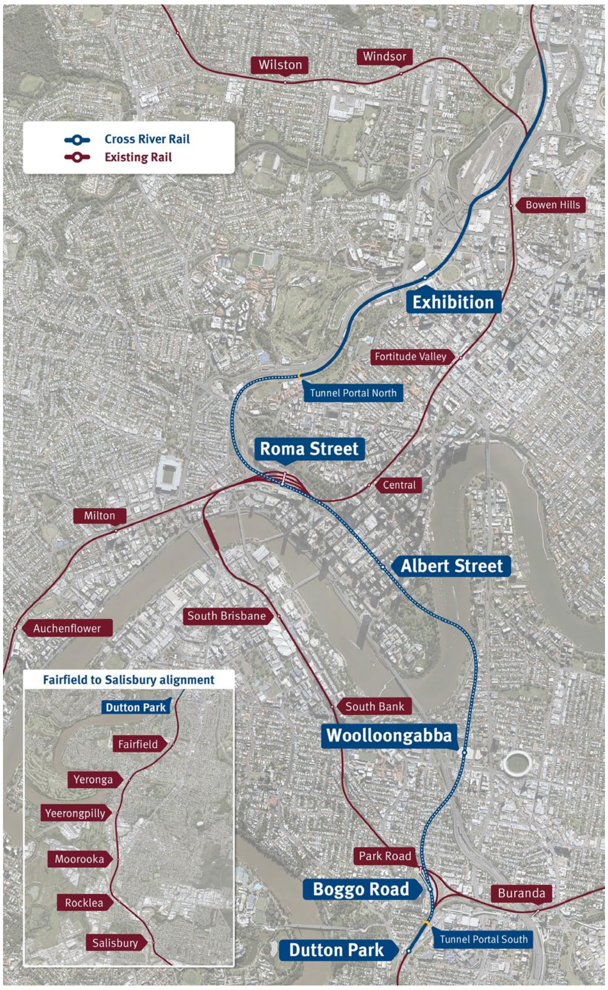


3. Case study

3.1. The project

The Cross River Rail project (CRR, "the project") is a major infrastructure project currently under construction that is centred around the city of Brisbane (see Figure 5).

Figure 5: CRR project alignment and infrastructure with locations of new stations (new stations south of Brisbane on the existing Gold Coast railway line not shown for visual clarity purposes)



CRR aims to address the increasing demand for public transportation, alleviate congestion, and improve connectivity within the city and the broader region. The project's focal point is the Brisbane River, which has historically posed a bottleneck for the existing rail network due to limited number of river crossings. The key components of the CRR project include:

New rail lines and higher service frequencies: The project involves the construction of a new section of underground rail line that runs through Brisbane city centre on a north/south alignment. This new section line is designed to provide additional capacity and enable higher frequencies on the existing rail network.

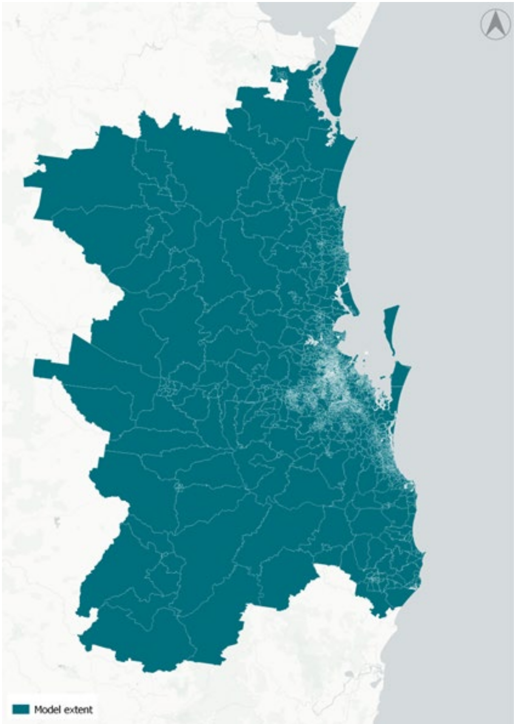
Additional stations and facilities: CRR includes new and upgraded stations at Albert Street, Exhibition, Woolloongabba, Boggo Road in Brisbane as well as Pimpama, Hope Island and Merrimac in the Gold Coast. These new stations greatly expand accessibility to the rail network, especially in the city centre.

3.2 Approach and assumptions

Strategic transport model

To assess the effects of CRR, we use the Zenith Strategic Transport Model of South East Queensland (SEQ) ("the Zenith model") complemented in one scenario by the land use model. The Zenith model covers the entire SEQ region as well as Northern NSW with 4507 travel zones. The granularity of zones increases in urban areas, such as the Brisbane Greater Capital City Statistical Area (Figure 6). The key attributes of the Zenith model are summarised in Table 1.

Table 1: Attributes of the Zenith SEQ model



Model extent	Characteristic	Model treatment
(map above)	Modelled day types	Average Weekday Daily Traffic (AWDT). This measure reflects the daily traffic on an 'average weekday' in which schools, universities, and workplaces are all in operation. The model results are not representative of demands during weekends or 'non-average' weekdays (e.g. school holidays).
	Modelled time periods	AM Peak (7am to 9am), PM Peak (4pm to 6pm), and Off-peak (remainder)
	Modes	Walk/cycle, car, light and heavy goods vehicles, bus, train, ferry and light rail
	Freight	Generated by employment and industry in each zone and unique areas such as ports.
	Induced demand	Changes in destination, mode and route choice

Modelling assumptions and scenarios

In this case study, we model three scenarios:

- 2031 Base Case (no CRR)
- 2031 Project Case (with CRR) – without land use modelling
- 2031 Project Case (with CRR) – with land use modelling

All scenarios include future committed or funded infrastructure upgrades (relative to a 2016 'existing year'), as are expected to occur in the absence of any project upgrades or investment. For simplicity, we made the Base Case rail frequency assumptions consistent with 2016 timetabled frequencies obtained from TransLink as rail service frequencies are infrastructure constrained. Table 2 summarises key funded and committed public transport projects that are included in all scenarios and describes how they are represented in the model.

Table 2: Funded and committed public transport projects by 2031 other than CRR

Project	Project Description	Representation in Model
Brisbane Metro	Replacing the existing busway services between Eight Mile Plains and Roma Street and between UQ Lakes and RBWH with high frequency Brisbane Metro services and infrastructure improvements.	Frequency increases on busway route 111 in accordance with Brisbane Metro (public information).
South East Busway Extension	Extension of the South East Busway from Eight Mile Plans to Springwood as	Busway extension to Springwood with new station and park 'n' ride at Rochedale, with

	a part of the Eight Mile Plains to Daisy Hill motorway upgrades.	connections to routes 576, 577, 586 (545 within 500m).
Loganlea and Beenleigh Rail Station upgrades	Station amenity improvements and relocation of Loganlea Station to the east of Loganlea Road to improve connectivity and upgrades to Beenleigh Station.	Reduced station access penalties at Beenleigh and Loganlea stations to reflect upgrades and Loganlea station relocation.

In addition to the above assumptions, the 2031 Project Case includes CRR, that is, new stations located at Albert Street, Exhibition, Woolloongabba, Boggo Road in Brisbane and Pimpama, Hope Island and Merrimac in the Gold Coast and increased rail service frequencies (+43% during the AM peak and +54% during the PM peak) and new stations.

Land use assumptions

Underlying population, employment and enrolment projections for 2031 were based on the Queensland Government Statistician's Office 2018-edition population projections, Queensland Treasury Regional Employment Projections (2010-11 to 2040-41) 2015-edition, and Queensland Government Department of Education data respectively. These projections are kept constant in the Base Case and Project Case when not modelling land use interaction, but are allowed to vary in the "with land use modelling" scenario. In the "with land use modelling" Project Case scenario, the adjusted demographics obtained from the land use model are fed into the travel demand model at the beginning of each loop in the process (refer to Figure 1). The resulting transport costs from the transport model are subsequently fed into the land use model. This process was repeated for 8 full iterations. Results presented hereafter are from this 8th and final iteration of the integrated land use and transport model process.

3.3 Results

Convergence of the integrated land use and transport model process

Figure 6 shows the stabilisation of demographics and transport costs by iteration relative to the base case. We can see that the model system converged quickly for both measures after only a few iterations and then stabilised. The process was ended after eight iterations and once transport cost gap[6] (see Figure 6 right) and population/employment gap (not shown) reached levels below the chosen threshold of 0.1% change relative to the previous iteration. Employment changes took until the second iteration to adjust. This highlights the importance of iterating between the transport mode and land use models to achieve a stable state. If only a single pass from transport model to land use model was done instead the resulting employment change would have been almost 50% lower.

[6] Transport cost gap here is defined as the sum of absolute differences in transport costs between iterations

Figure 6: Change in population and employment (left) and transport cost gap convergence (right) by iteration

Changes in population and employment

In response to CRR, the land use and transport model predicts a decentralisation of population and a centralisation of employment. From an urban economic perspective, this outcome is intuitive: CRR improves the relative accessibility of the city centre, thereby supporting employment in a relatively productive part of the city where access to the biggest pool of workers is maximised. In contrast, CRR allows residents to relocate out to amenable and relatively cheaper (often coastal) locations north and south of the city.

In terms of the magnitude of the effects in and around Brisbane's city centre, we find that population decreases by around 2-3% (Figure 7) whereas employment increases by around 6-7% (Figure 8). We find population increases in suburbs to the north (North Lakes, Kippa Ring, Deception Bay and Burpengary), west (Ipswich and Rosewood), east (Birkdale, Wellington Point and Cleveland) and south and areas in the vicinity of the new infill stations in the Gold Coast (Pimpama, Hope Island, Worongary and Merrimac). These areas are all locations that see a boost in rail frequency and access due to the CRR project.

Employment is drawn to the CBD and inner Brisbane area from across the SEQ region with notable decreases in areas to the north and west. This suggests that, with CRR in place, the increased accessibility to central areas causes employment to centralise to where access to the most workers is possible.

Figure 7: Change in population by SA2

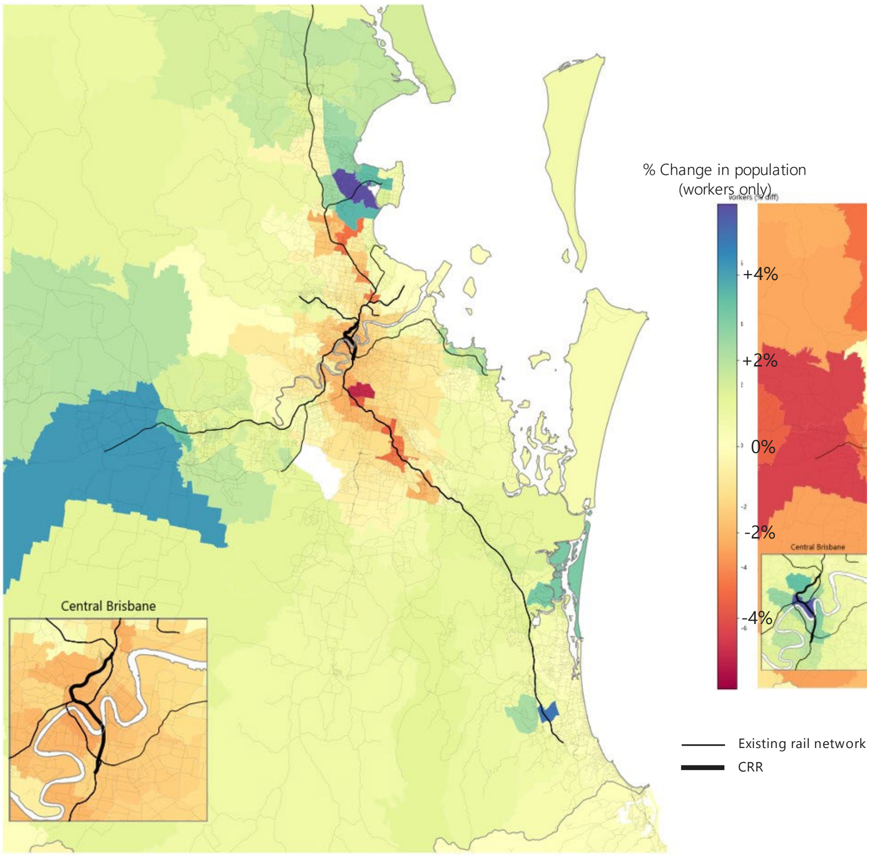
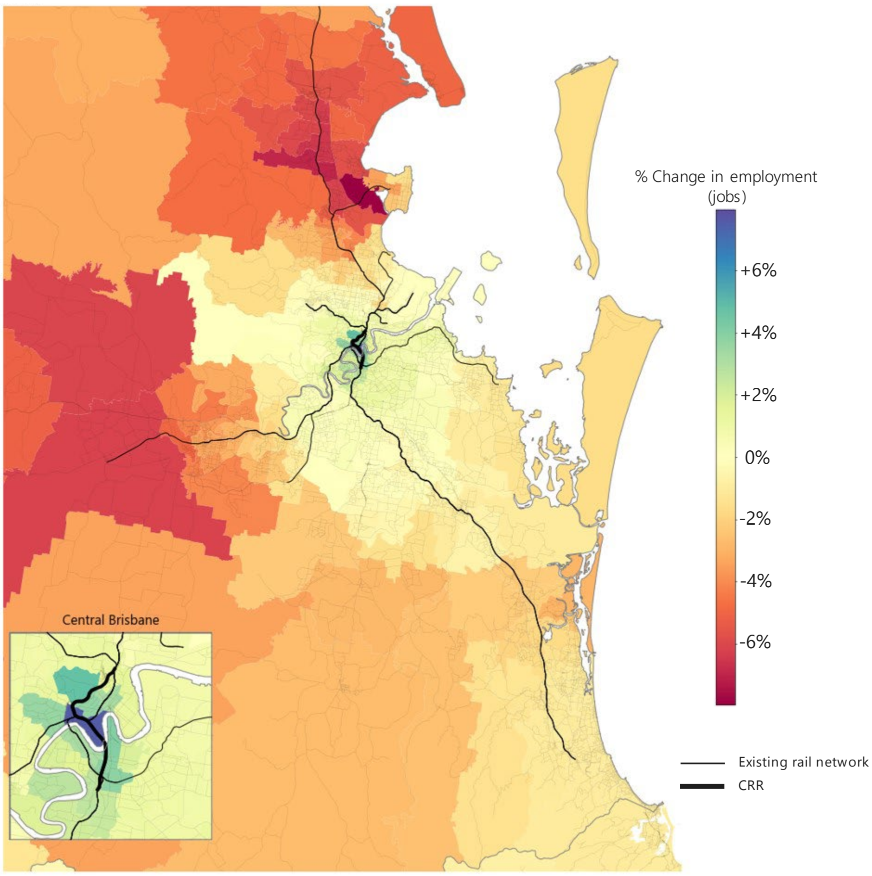


Figure 8: Change in employment by SA2



Transport outcomes

CRR leads to increased rail boardings in all time periods, which is further magnified when we allow for land use change (see Table 3 results) where + 2% is added to boardings.

Table 3: Rail boardings by time period – model wide

Time period	2031 Base Case	2031 without land use modelling	2031 with land use modelling	Change with land use model	% diff
AM peak	89,500	101,300	103,700	+2,400	+2%
PM peak	75,700	89,600	92,100	+2,500	+3%
Daily	358,000	405,200	414,600	+9,400	+2%

Without land use change, the project results in a decrease in car and active transport trips and an increase in public transport trips. With dynamic land use we see a further reduction in car trips by 0.2% and an increase in public transport trips of around 1.4% (see Table 4), although we now find that the demand for active transport increases—likely due to the relocation of people and jobs into accessible locations facilitating shorter trips for non-work purposes. Model wide mode shares are shown in Table 5.

Table 4: Trips by mode – daily - model wide

Mode	2031 Base Case	2031 without land use modelling	2031 with land use modelling	Change with land use model	% diff
Car	12,112,600	12,103,100	12,075,800	-27,300	-0.2%
PT	931,000	947,900	961,600	+13,700	+1.4%
Walk and Cycle	4,340,500	4,334,100	4,347,900	+13,800	+0.3%

Table 5: Mode share in trips – daily - model wide

Mode	2031 Base Case	2031 without land use modelling	2031 with land use modelling
Car	69.68%	69.62%	69.46%
PT	5.36%	5.45%	5.53%
Walk and Cycle	24.97%	24.93%	25.01%

Table 6 shows the boardings and alightings at all new stations delivered under CRR project during the AM peak. We see increases in boardings and alightings at all new stations under the dynamic land use scenario compared to the static land use scenario with increases of around 2-5%.

Table 6: Alightings plus boardings at new rail stations – AM peak

Station	2031 Base Case	2031 without land use modelling	2031 with land use modelling	Change	% change
Albert Street	-	8,150	8,560	+410	+5%
Woolloongabba	-	1,320	1,360	+40	+3%
Exhibition	-	3,060	3,200	+140	+5%
Boggo Road	-	220	220	0	0%
Pimpama	-	310	320	+10	+3%
Hope Island	-	940	980	+40	+4%
Merrimac	-	1,210	1,230	+20	+2%

Economic appraisal

Table 7 presents the economic analysis of the CRR project under both static and dynamic land use conditions. Overall, the economic outcomes of the case study demonstrate that dynamic land use allows for model-wide network efficiencies that, in our model of SEQ principally decrease private vehicle user vehicle operating costs (VOC), travel times as well as also increasing safety and externality benefits. This surprisingly car dominated response is because car mode share (approximately 70%) is significantly higher than public and active transport in SEQ, meaning that small decongestion benefits model-wide for many car users results in large benefits in aggregate. Public transport user travel times also increase slightly due to the relocation of people and jobs to areas that are more accessible with CRR in place (this lengthening of in vehicle travel time is however offset by reduced wait times with the higher frequency due to CRR). Overall, the use of dynamic land use in the appraisal leads to a 34% uplift in estimated project benefits compared to using static land use. We emphasise these are "conventional transport benefits", rather than "wider economic benefits" and only represent the monetisable benefits.

Table 7: 2031 Economic outcomes ($ December 2022 millions, real, present values (PVs) undiscounted)

Benefits	2031 without land use modelling	2031 with land use modelling	Change
User benefits	**276**	**358**	**30%**
Private vehicle user travel time savings	55	75	37%
Vehicle operating costs (VOC)	70	114	63%
Private vehicle user travel time reliability	5	6	37%
Public transport user travel time savings	147	164	11%
Safety related benefits	**8**	**20**	**143%**
Vehicular externalities	**2**	**7**	**183%**
Total economic benefits	***286***	***385***	***34%***

4. Discussion

4.1 Limitations and alternatives

Our model builds on the approach in Ahlfeld et al. (2015). Two notable potential limitations of this model include the “closed city assumption” and the assumption that prices for consumer goods are unaffected by transport costs. Although we expect these assumptions are reasonable for most schemes, they may be problematic when considering the effects of extremely large projects. The model in Ahlfeld et al. (2015) also focuses on the role of commuting trips in location choice for households and firms, which has a long history in the literature (see Alonso (1964), Muth (1969), Mills (1967), and Wheaton (1974)). Although we extend the model to capture effects on non-work transport costs, our approach is still clearly a simplification. More complex methods might allow for richer interactions between transport costs and location choices (for example full Computable General Equilibrium (CGE) models), although these may incur a large burden in terms of data, complexity, and run-time.

Our approach also assumes that there exists a static equilibrium in land use and transport outcomes. Simmonds et al. (2013) criticise static methods for ignoring potential dynamic processes. We respond to this criticism in three parts. First, we can model the effects of projects in the future, after dynamic effects are expected to have stabilised. In our case study, for example, we model effects in 2031, which is more than five years after CRR expects to open. We expect the predictions of static and dynamic models to converge in the long run. Second, we note that dynamic SGE models are an active area of research (see, for example, Lennox, 2023). Such models typically build on the foundations provided by static models, although extend them to incorporate expectations—such that people and firms can anticipate the effects of a project. Third, although our analysis relies on an SGE model, we do not preclude the use of other quantitative methods. We expect, moreover, that different methods will give rise to somewhat similar predictions, even if the magnitude of the response varies. The reason for this is because all models allow the location choices of people and firms to be endogenously determined with transport costs---that is, to move towards accessibility.

We see two clear alternatives to the use of land use models. First, we could maintain the status quo of assuming fixed land use between base and project case scenarios. This approach, however, runs contrary to a large and rapidly growing body of economic research that clearly shows that land use and transport are endogenously determined. As such, we suggest the status quo is indefensible, at least from a scientific perspective. Second, we might allow the people who are appraising and modelling projects to manually adjust the underlying land use assumptions in the project scenario, for example, using their professional judgment. This approach, however, would seem to be ad-hoc and prone to a lack of transparency that, in turn, caused problems with strategic misrepresentation and optimism bias (Flyvbjerg, 2008).

4.2 Model convergence

Here, we apply the same threshold criteria used for strategic transport model demand / supply convergence for the threshold in our integrated land use and transport model system. The lack of guidance on suggested convergence thresholds for integrated land use and transport modelling systems is a gap in the literature that if filled could be of benefit to practitioners.

More broadly, the criticism of Simmonds et al. (2013) that the assumption of equilibrium in land use and transport is not realistic can be also levelled at the assumption of convergence in land use / transport modelling. Our approach assumes that the land use and transport system was already at equilibrium in the Base Case. The Project Case change just moves the land use and transport network to a different equilibrium point. The realism of this assumption is clearly debatable, but not unique to when land use is modelled in interaction with transport, rather this more broadly applies to criticisms of transport models in general. We believe our approach is pragmatic: Models have an important role in decision making and the assumption of equilibrium is not unreasonable given the use cases for these tools. Modelling the land use response to transport does not, in our view, affect these arguments.

4.3 Economic appraisal limitations

The transport benefits calculated for the case study with and without dynamic land use show that most of the increase in benefits identified in the dynamic land use case accrued to private vehicle users. The high car mode share in SEQ is partly the reason for this outcome, where small changes in car travel times lead to small benefits for all road users which, when summed over the whole model area equate to large total benefits.

More fundamentally, undertaking conventional economic appraisal on transport modelling results using the consumer surplus 'rule of a half' approach while allowing land use to change could be said to invalidate the assumptions that underpin conventional economic appraisal. This is because when land use is fixed ("static"), the gross utility of a trip—that is, the utility associated with getting to the destination plus the utility of using a specific travel mode—does not vary between base and project scenarios. This means changes in utility are entirely attributable to changes in the transport costs that are faced by users. In turn, for a given origin-destination and mode, changes to transport infrastructure and/or services in the project case simply serve to shift the supply curve, while the demand curve is assumed to only be able to swivel around a point, where a change in slope reflects change in demand elasticity in response to change in supply, but maintaining the same gross utility. When land use changes, however, the gross utility of some individuals' trips will plausibly also change, thus shifting the transport demand curve inwards or outwards as well. The conventional application of rule of half therefore no longer represents a valid approximation of transport user benefits—or consumer surplus—that is attributed to the project. Economic appraisal in the presence of land use change therefore requires new methods like that outlined by Parker (2013), or direct analysis of the "logsum" results from the integrated transport and land use model itself.

Finally, we also note that traditional cost-benefit analysis does include potential social benefits driven by better transport outcomes, such as option values for PT services and social inclusion benefits, e.g. for travellers without access to a car.

4.4 Generalisability of land use response results

Our results are generally consistent with other recent Australian studies that have looked at the impact of transport improvements on land use through integration of strategic transport models and land use models (see VLUTI model used in Victoria, Le et. al, 2023), and the effects we should expect to see when long distance transport accessibility increases in urban areas (see Baum-Snow, 2007).

In our case study results we noted population decreases in the CBD of Brisbane with the CRR project in place but a subsequent increase in employment. Population is displaced from central Brisbane to suburbs that see a boost in rail frequency and access due to the CRR project whilst employment in these outer areas reduces at the expense of the centralisation of jobs in central Brisbane. This centralisation of jobs where access to workers is improved with the CRR in place is consistent with the notion that firm location choice factors in where they can access the most workers, whilst for workers, improved accessibility means the ability to relocate to relatively cheaper residential locations now within the same commute time envelope. This pattern of movement and magnitude of change may be generalisable to other urban contexts and transport changes that have the purpose of improving access to central urban areas with high densities of jobs. Further work to understand how differences in outcomes for public transport and road infrastructure may differ or produce similar effects is needed.

5. Conclusions

In this paper, we have presented an approach to land use and transport interaction using a simplified SGE model. First, we outline the extensions of our model to account for non-work travel costs and monitor convergence across both transport and land use models. Second, we consider implications of land use change for the economic appraisal of transport projects. Third, we document a case study for a recent major public transport project in Brisbane, Australia. Results show that allowing for land use change has significant implications for conventional economic benefits, which are estimated to be 30-40% higher than scenarios where land use is held fixed. Fourth, we discuss some of the limitations of our analysis. Notwithstanding the latter, we conclude that quantitative spatial models have important implications for our transport policies.

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