MERIT

Short Overview Document

Prepared for: NZTA

Date: June 2016
Status: Draft Final

me spatial

MERIT

A Short Overview Document

Prepared for New Zealand Transport Agency

Authors: Nicola Smith and Garry McDonald
Market Economics Ltd, Takapuna, Auckland

www.me.co.nz

Market Economics Limited
Level 5, 507 Lake Road
PO Box 331 297, Takapuna
Auckland 0740, NZ
P 09 915 5510

Introduction to MERIT

'MERIT' (Modelling the Economics of Resilient Infrastructure Tool) is a dynamic, multisectoral economic model developed primarily under the Economics of Resilient Infrastructure (ERI) programme, a four-year research programme funded by the Ministry of Business, Innovation and Employment.

MERIT was designed to imitate core features of a Computable General Equilibrium (CGE) model. CGE models tend to be the favoured approach and 'state-of-art' in the modelling of regional- and national-level economic impacts. Among the advantages of these types of models are the whole-of-economy coverage, the capture of not only *indirect* (i.e. the so-called upstream and downstream multiplier effects generated through supply chains) and *induced* (i.e. as generated through household consumption) economic consequences, but also of the 'general equilibrium' (pricing) impacts.

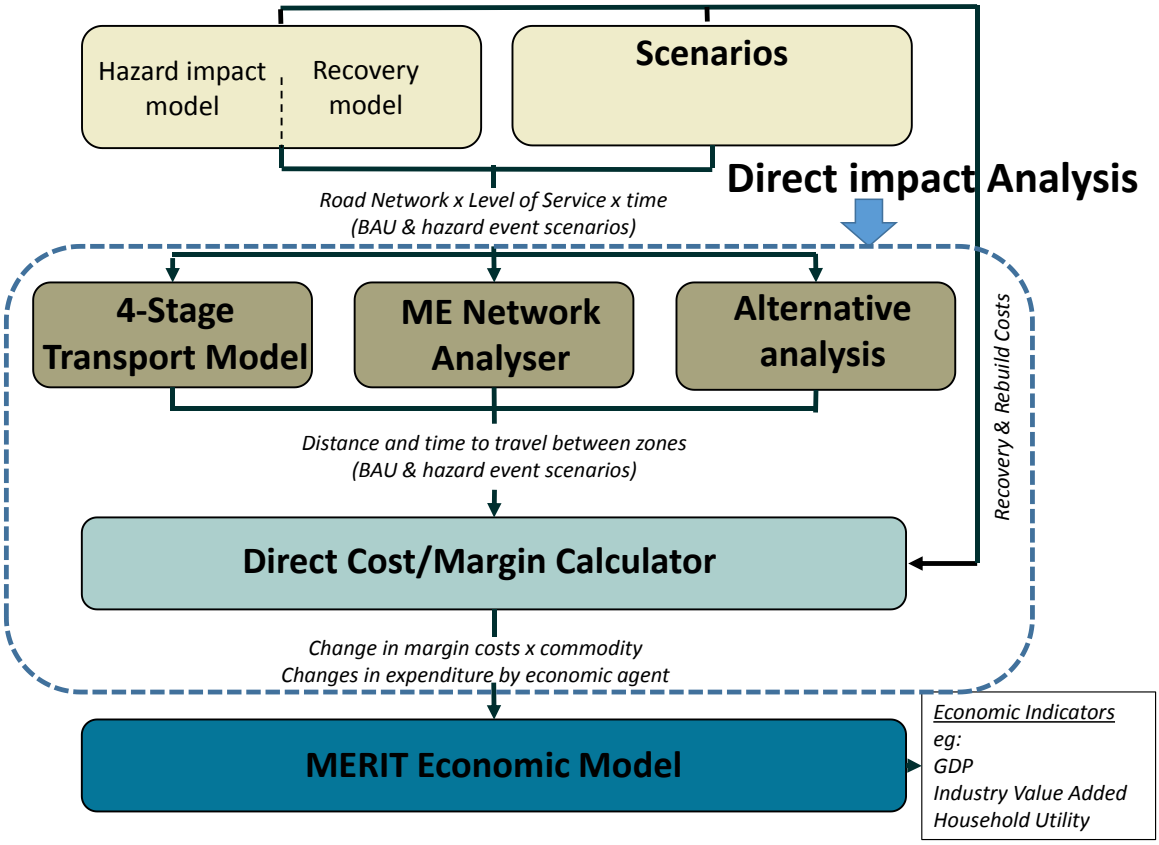

Figure 1: Analytical Tools and Steps Required to Undertake an Analysis of a Road Outage using MERIT

It is important to note that while MERIT incorporates core features of a CGE model, it differs from a 'standard' CGE model in that it is a System Dynamics model formulated using finite difference equations. This is an innovative extension to economic modelling undertaken to improve our ability to capture the impacts of infrastructure outages. Standard economic models are 'equilibrium' models that describe conditions existing in an economy when a set of pre-determined conditions are met i.e. supply equates to demand for all commodities and factors, and income equates to expenditure for all economic agents. For the analysis of infrastructure outages, however, an equilibrium-based analysis is often not useful, as the time to reach equilibrium will often be longer than the actual length of the

infrastructure outage, and during the period of disruption the economy is likely to exhibit non-equilibrium behaviour e.g. industries may be operating at a loss. MERIT is a *simulation* model that shows a *transition pathway towards equilibrium*. It is not necessary that an equilibrium is actually achieved, and indeed the equilibrium towards which the economic system is moving may continue to change over time.[1]

It is also worth noting that building an economic model such as MERIT is an important, but not sufficient step required to evaluate the economic consequences of system shocks, such as road or other infrastructure outage. In the case of road outage scenarios, for example, a number of pre-processing steps are required before a road outage scenario is translated into a set of inputs that enter directly into MERIT. A road outage scenario itself may be provided simply as narrative to be translated into physical descriptions of impacts on the road network, or potentially based on independent hazard impact models with possible further modelling of recovery pathways. In the middle of Figure 1 a number of data and information processing steps are required which we have grouped together under the label 'direct impact analysis'. As part of this analysis of direct impacts, it will often be necessary to enter information from the road outage scenario into a transportation model, so that we can understand the direct impacts on economic agents in terms of increased travel costs for different types of transport purposes. Depending on the circumstances of the scenario, this may even require use of a full four-stage transport model.

Once information is transformed into appropriate inputs and the model run, MERIT is able to produce a variety of indicators to help us evaluate the impacts in aggregate and by industry of an infrastructure outage, including GDP, regional value-added (similar to a regional equivalent of GDP), value of exports and imports, and household utility. It is worthwhile noting that the latter indicator is conceptually consistent with measurements that are sought to be calculated in a cost-benefit analysis. MERIT thus has the potential to be used for cost-benefit analysis as well as economic impact analysis.

A full technical report for MERIT is currently being prepared and is likely to be available from mid-2016 (Smith *et al*., 2016). The purpose of this short report is to provide a concise overview of the model including description of key assumptions and limitations.

[1] It is however worth noting that under a 'no growth' scenario, MERIT and a 'normal' CGE model (specified using the same underlying equations) will produce identical results – if MERIT is run to a point where supply and demand prices have equilibrated. The key difference between the two models is, however, MERIT records the transition pathway towards equilibrium, while a normal CGE model will only show results for the equilibrium solution.

Key Assumptions

Some of the key assumptions that underpin the model's structure are as follows:

- *Agent Behaviours* - For each economic region, the economy is described by the behaviour of a group of representative agents (20[2] industries, households, local government, and central government). Industries are assumed to make choices about production and consumption solely based on the relative costs of inputs and values of production. Household and government agents receive income from a variety of sources (including from wages and salaries, business profits, dividends, taxes and transfers from other agents) and, in turn, allocate this income to a variety of expenditure options (purchases of goods and services, savings, taxes, and transfers to other agents).
- *Functional Forms* - Like many CGE models, MERIT also repeatedly relies on the Constant Elasticity of Substitution (CES) and Constant Elasticity of Transformation (CET) functional forms to represent alternative demand (input) and supply (production) choices. 'Nested' CES production functions allow the economy to react to imbalances between supply and demand in commodities/factors, through substitution of demand and/or production. These substitution possibilities occur in response to changes in relative prices. For example, a CES function describes the way in which demand for New Zealand-manufactured goods can be substituted for demand for goods produced overseas, if the price of domestic goods becomes too expensive relative to foreign goods. A separate CES function also describes the substitution between local-manufactured goods (i.e. produced within the same region) and the goods produced in the rest of New Zealand.
- *Prices and Time Lags* – As already explained, MERIT is a dynamic model able to describe not only the distribution of economic impacts across different sectors, but also the distribution of impacts *through time*. This extension to CGE modelling is achieved essentially by creating price levels for all commodities and factors of production (i.e. labour and capital). Changes in these prices are determined each model iteration,[3] and the new prices computed serve as inputs to the next model iteration. A key assumption is that all prices adjust upwards when supply is less than demand, and downwards when supply is less than demand. The model does not, however, attempt to compute the prices necessary to reach equilibrium such that supply equals demand for all items. It is the time lags in price adjustment and the way in which these all interact over time, that manifest the dynamic behaviours captured by the model. The parameters that determine the extent to which prices move in response to imbalances between supply and demand are set via model calibration.
- *Other Parameter Estimation* - The model incorporates a large number of other input parameters. Due to limitations in the availability of official statistics, and the significant resource required to develop alternative datasets, we have developed a full set of economic

[2] The number of industries and commodities specified in the model can be changed. For online applications of the model we must make a trade-off between aggregation of industry/commodity definitions and reducing processing times and keeping within available memory.

[3] Each iteration represents approximately one day.

accounts only for a single year.[4] These accounts, termed a Social Accounting Matrix (SAM), are based on the 2006-07 financial year in accordance with the national supply and use tables released by Statistics New Zealand. Many of the input parameters are derived from this SAM (e.g. CES share and scale parameters, proportion of household income transferred overseas, commodity inputs required per unit of production), and are set as constant over a model run. It is thus assumed that relationships and behaviours exhibited during the 2006-07 financial year are a good approximation of relationships/behaviours in future modelled years.

- *Market Simulation versus Cost Benefit Analysis* – MERIT is specifically designed as an Economic Impact Assessment tool – i.e. it *simulates* market behaviours. It thus helps us identify, explain and understand the dynamic relationships existing in the economic system. Although on its own MERIT is unlikely to provide all of the information necessary to assess policy trade-offs, it can provide useful inputs to such evaluations. For example, MERIT could provide information on the general equilibrium outcomes of road outages under a hazard impact scenario, with and without mitigation investments, for a cost benefit analysis. Note however that for such information to be properly incorporated into a cost benefit analysis, it would be necessary to weight the outcomes of the MERIT runs according to the appropriate risk/probability profiles.

Limitations

To complete this short report we provide a brief overview of some of the limitations that are important to keep in mind with regards to MERIT.

- *Novelty* - As far as we are aware, MERIT is unlike any economic model that has been developed within New Zealand or elsewhere. Because MERIT is novel, it has not had the benefit of years of reflection and refinement.
- *Further Calibration* - Relating to the preceding point, the research team is still in the process of undertaking calibration of MERIT and sensitivity analysis. Significant further opportunities exist to test components of the model against real data where possible. For example, the research team would like to try and source further data on the response of export demands to changes in price to help further calibrate the export elasticity of demand parameters used within the model. We are keen to obtain examples of historic road and other infrastructure outages, provided accompanying economic information is also available, to help improve the calibration of the model.
- *Uncertainty Analysis* - Our ability to understand and interpret the outputs of MERIT would also be advanced by dedicated work on uncertainty analysis. The research team has identified this as a key topic for further work should research funds become available.
- *Model resolution* - The economic accounts currently available for input within MERIT are formulated according to the boundaries of NZ regional councils. This means that when running MERIT we currently report the study region (i.e. the locality in which the impact occurs) as a whole regional council boundary, for example Manawatu-Wanganui region. However, when an infrastructure outage affects a part of a region more intensely, there will

[4] Statistics New Zealand recently released a new set of national supply and use tables for the year ended March 2013. Accordingly M.E will be undertaking an update of its multi-regional SAMs. This will effectively provide a full set of economic accounts for two years and improved capabilities for calibration.

clearly be some uneven distribution of impacts within the region. Although the MERIT model is set up to receive economic accounts for varying spatial boundaries, it is important to note that the establishment of these accounts (SAMs) is a very laborious process. Also related to model resolution, we have a set number of 'average' commodities traded by 'representative agents' within each region. When modelling changes in transport margins (freight costs) we must therefore implement the average change in margins across each study region. In reality changes in transport margins might show quite significant spatial variation within each region.

- *Extension of direct impact analysis to cover further impacts* – Although this might not be considered part of the core MERIT model itself, it is worthwhile noting that the algorithms thus far developed for translating changes in road network levels of service into input parameters suitable for MERIT do not yet cover all of the potential impacts of road outages on the economic system (see Table 1).

  For the road outages thus far trialled (i.e. SH4 between Raetihi and Wanganui, Manawatu Gorge, and West Coast highways under an alpine fault scenario) it is likely that changes in transportation margins on commodities (i.e. freight costs) are the most significant impacts, along with likely small changes in household travel costs to work. In some rural contexts tourism impacts will also be significant. When analysing tourism impacts it is, however, important to distinguish between transfers in tourism demands, and net losses in tourism expenditure.

  When analysing road outages, particularly in an urban context, it is also important to consider whether the outage is likely to generate significant changes in the numbers of people choosing to travel to work, which can have significant economic consequences by reducing the labour factors of production. Further work is necessary to define with confidence the thresholds at which choices are made by individuals not to attend work when subject to changes in travel costs. Furthermore we recognise that businesses have some inherent and adaptive resilience to short term disruptions. For example, some employees can still undertake work at home, and production can be recaptured by working overtime and rescheduling. Further research is required to define the extent to which changes in travel to work result in losses in economic production, and how this also varies between economic industries.

Table 1: Road Outage Impacts Covered by Direct Impact Analysis for MERIT

Impact	In the model		Possible?	Not in the model	
	Complete	Method identified		Non-market	Outside scope
Freight					
Time costs	X				
Vehicle operating costs	X				
Emission costs				X	
Perisable commodities					
Loss of product			X		
Loss of product value			X		
Tourism					
Loss of tourism spend					X
Loss of scenic value				X	
Travel to work/school					
Time costs				X[1]	
Reduced supply of labour		X			
Vehicle operating costs	X				
Emission costs				X	
Shopping					
Time costs				X[1]	
Vehicle operating costs	X				
Emission costs				X	
Recovery and rebuild					
Increased construction		X			
Opportunity costs of capital		X			
Business to business travel					
Loss of staff time		X			
Vehicle operating costs		X			

1. MERIT could be adapted to include but thus far only considers market impacts