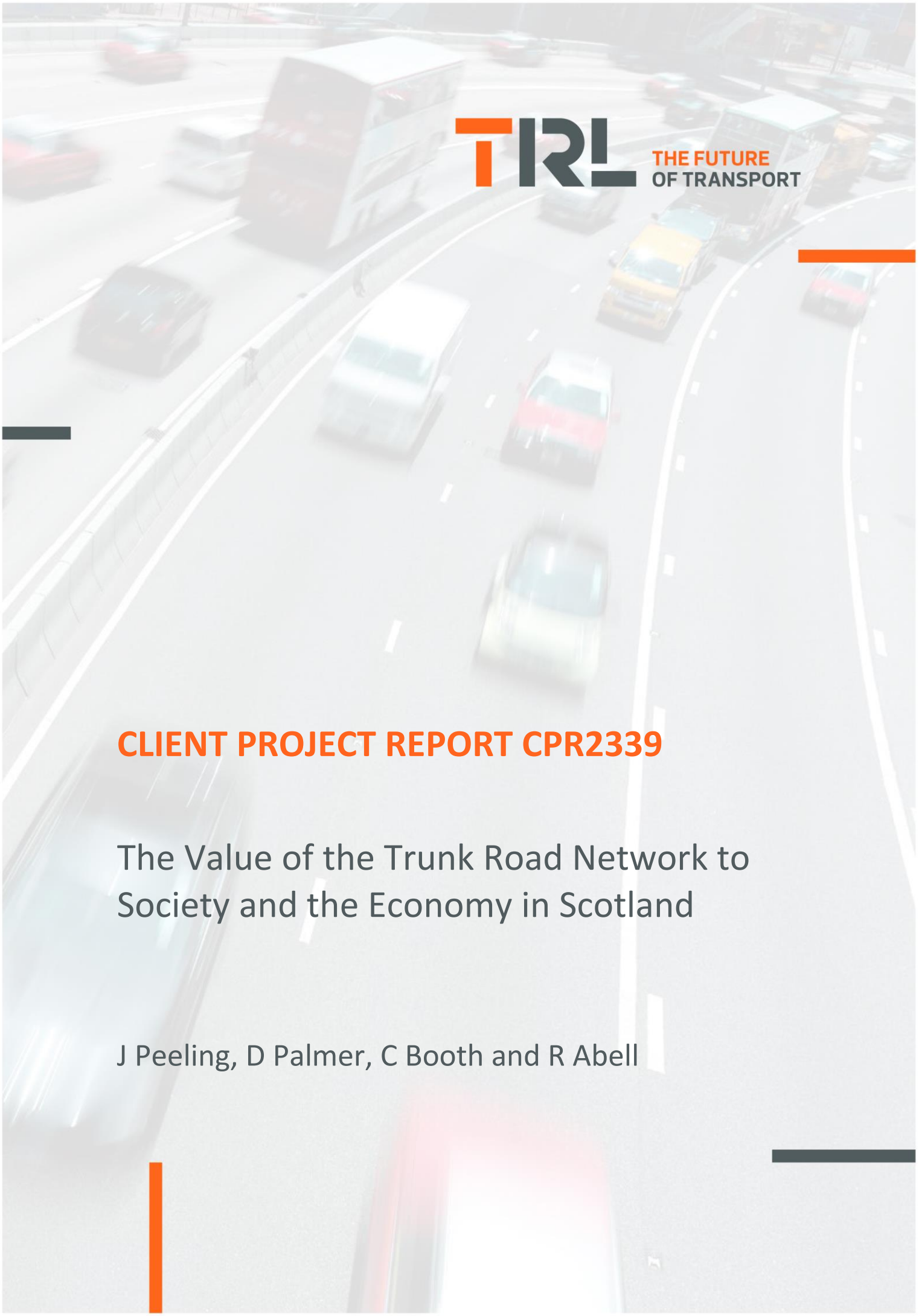

THE FUTURE OF TRANSPORT

CLIENT PROJECT REPORT CPR2339

The Value of the Trunk Road Network to Society and the Economy in Scotland

J Peeling, D Palmer, C Booth and R Abell

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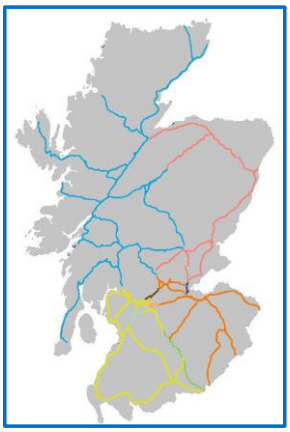
Value of the Trunk Road Network (TRN) to Society and the Economy in Scotland

Quantified benefits of the TRN

Contributes
£1.38 billion
in Approximate Gross Value Added (aGVA)

Per capita aGVA of £44k



Generates employment for
31,000 people
(1.2% of all Scotland)

Generates £358 million
in tax receipts

Road Traffic Accident (RTA) Savings of £171 million
in accident costs

Using the TRN instead of local roads saves travel time costs of £1.64 billion

CO_2 emissions, valued at £6 million, saved by using the TRN instead of local roads

Non-quantified benefits of the TRN

The TRN delivers benefits to all sectors of the economy and is fundamental to the success of sectors such as food & drink, and tourism.

Inclusive growth

Lifeline transport link
Connects communities across Scotland and provides a lifeline transport link in remote areas. A well-maintained TRN is essential as poor road transport links can leave areas isolated.

Enables access to education, jobs and services for all
The TRN is used by buses, the prime mode of transport for many excluded and/or low income groups, including the elderly, job-seekers and people with disabilities.

Other socio-economic benefits

Freight benefits
Fewer freight vehicles required and increases in freight distribution centres

User benefits
Provides access to essential service to users and operators

Labour market effects
More people willing to enter the labour market and to work longer hours

Wider economic impacts
Covers agglomeration, imperfect competition and benefits of increased employment

Executive Summary

Background

TRL was commissioned by Transport Scotland to assess the contribution of the Trunk Road Network (TRN) to Scotland's economy in order to demonstrate the importance of continued investment in that part of the road network in Scotland. The aim was to address the gap in the evidence base on the societal and economic value of the TRN. The project involved undertaking a literature review of UK and international evidence, and undertaking economic analyses and a review of economic assessment methods. A spreadsheet economic analysis tool (VaTSE – Value of the Trunk road network to Society and the Economy), based on assessing the Gross Value Added (the value of goods and services produced in an area of the economy) and other impacts of the TRN, was developed to provide a quantitative basis for the conclusions. Two types of impacts were studied: economic and social. This report describes the quantified benefit of the TRN to society and economy in Scotland, and describes the societal benefits that cannot be assigned a financial value.

Economic impacts

Scotland's TRN is one of the major infrastructure assets in the country with a gross asset value of over £20 billion. The TRN has a significant economic impact, facilitating employment and enabling economic and societal activities across Scotland. It connects different areas and communities of Scotland, providing both economic and social opportunities for individuals and business.

Using the VaTSE model, the TRN was estimated to contribute around £1.38 billion approximate Gross Value Added (aGVA) each year through the activities of road freight, public transport and road construction and maintenance on that part of the road network. In addition it provides a significant service to commuters and employees travelling on business. Per capita aGVA from the TRN is about £44,000.

Estimates show the Scottish TRN directly supports more than 31,000 jobs across the economy – approximately 1.2% of all jobs in the country, through road freight operations, public transport and the construction and maintenance work on the TRN. The direct jobs created and supported by the TRN generate annual tax contributions of around £358 million (from PAYE, Corporation Tax and VAT) from which all of Scotland's economy benefits.

Businesses benefit from use of the TRN through access to domestic and international markets. The TRN provides economic benefits for road users through travel journey time, and therefore cost, savings on the TRN relative to other roads. Lower journey times and lower costs for businesses can also be of benefit to consumers as a whole when they are passed on in the form of lower prices. Using the TRN saves travel time costs of around £1.64 billion per year.

For Scotland's tourism industry, an efficient TRN enables it to successfully compete with international competitors and attract worldwide visitors, by offering safe and efficient access throughout the country including remote tourist destinations. By offering quicker journey times relative to other roads, the TRN also helps Scotland's food & drink industry to compete internationally.

Investment in the TRN leads to economic benefits to the wider economy such as agglomeration externalities – the benefits that firms obtain by locating near each other, greater competition and increased employment in other parts of the economy as well as productivity gains. The TRN enables more people to enter the labour market by reducing travel times and this leads to work longer hours. It provides employers with access to a wider range of potential employees.

The network provides an essential service to communities, businesses, leisure travellers and freight operators. It is used to transport fresh and high quality products around the country, which are then sold throughout the UK and in global markets. It enables more efficient delivery patterns reducing the number of goods vehicles required as well as improved operation of freight depots and distribution centres.

Societal impacts

The TRN in Scotland has beneficial societal impacts. Investment in the TRN improves communities' access to a range of opportunities: education, employment, healthcare as well as leisure activities, especially those in remote rural areas. Increased connectivity delivered by the TRN positively impacts on rural and remote communities and reduces regional inequalities in accessibility, benefiting regional cohesion.

The TRN promotes inclusive growth through:

- Lifeline transport links: Connecting communities across Scotland and providing lifeline transport links in remote areas. A well maintained TRN is essential as poor road transport links can leave areas isolated.
- Access to education, jobs and services for all: The TRN is used by buses, the prime mode of transport for many excluded and/or low income groups, including the elderly, job-seekers and people with disabilities.

Based on 2014 data, the extra accidents on the non-TRN if it carried the TRN traffic would cost approximately £171 million per year more than the accidents on the TRN.

The TRN has a lower rate of carbon dioxide (CO_2) emissions than non-TRN roads with the same redistributed TRN traffic. CO_2 emissions in Scotland would increase if only non-TRN roads were used to carry TRN traffic. Use of the TRN reduces the cost of CO_2 emissions by around £6 million per year.

1 Introduction

TRL has undertaken this study for the Scottish Roads Research Board (SRRB) on the Value of the Trunk Road Network (TRN) to Society and the Economy in Scotland. This report describes:

- The results of a literature review of related past and current work in this area including the economic and societal benefits that the TRN brings to Scotland
- The development of, and findings from, a model to assess the benefits where the value of the TRN to the society and economy in Scotland can be quantified

1.1 Background to project

The TRN with a gross asset value of over £20 billion (Transport Scotland, 2016a) provides and facilitates employment, and supports economic activities across Scotland. It connects different areas and communities of Scotland, providing both economic and social opportunities for individuals and business. Transport Scotland commissioned this report to examine the wider value of the TRN to the economy and society in Scotland, recognising that there were gaps in the evidence base on the wider value of the trunk road network to society and to show the importance of the link between investment in the trunk road network and the economy and by quantifying the value added by trunk roads.

Previous work in this area for Transport Scotland (Parkman *et al.*, 2012a), the RAC Foundation (Gould *et al.*, 2013) and the Department for Transport (Buckland *et al.*, 2015) has looked at the societal benefits from road maintenance spend. In particular, the work for Transport Scotland as part of the National Maintenance Review considered the benefits for both the strategic and local road networks and included a literature review for similar work in the UK and overseas. The study for the Department for Transport also considered the benefits from levels of employment in the road maintenance sector. Less attention was paid to the benefits arising from trunk roads generating employment and output. The results from the earlier work provided a starting point for this study.

1.2 Objectives

The aim of this study was to address the gap in the evidence base on the societal and economic value of the trunk road network. The project had the following[1] objectives:

1) To undertake a literature review of UK and international evidence
2) To undertake economic analyses of the impacts

1.3 Report structure

This report contains:

[1] A third objective to review the use of the Highway Maintenance Assessment Toolkit has been reported separately (Abell *et al*, 2016)

- Literature review of UK and International evidence (Section 2)
- Value of the Trunk Road Network to the Society and the Economy (VaTSE) Model (Section 3)
- Conclusions and recommendations (Section 4)

References and a Glossary are provided in Section 5 and Section 6 respectively.

Appendices contain further information to support the other Sections of the report:

- Appendix A – Results from the literature review
- Appendix B – A summary of the relevant documents in the initial sift of the literature review
- Appendix C – Quantitative assessment methods/frameworks including STAG, WebTAG and TBC
- Appendix D – Screenshots from the VaTSE model
- Appendix E – Data sources for the base case analysis
- Appendix F – Parameters used for the sensitivity testing

2 Literature review

A literature review was carried out to consider:

- The societal and economic impacts of the TRN
- Possible methodologies for quantifying the contributions of the TRN to Scotland's economy and, where possible, the societal impacts

TRL studies by Parkman *et al.* (2012a), Parkman *et al.* (2012b) and Parkman and Bradbury (2012) for the National Road Maintenance Review for Scotland included a literature review of the economic, environmental and social impacts of road maintenance. The results of that work were investigated to identify relevant sources of information for this study of the Trunk Road Network.

A further literature search of recent articles, conference papers and published reports from UK and abroad was conducted using the web and electronic document databases available to TRL. In addition, documents provided by the Transport Scotland Project Team were reviewed.

2.1 Results of literature search

The literature searches produced a total of 67 references (10 provided by the Transport Scotland Project Team). A full list of these references is given in Appendix A.

The relevance of all the documents was assessed for reference to societal and economic impacts, the TRN, communities in Scotland or economic quantification methodologies. Of the 67 documents, 26 were classified as particularly relevant (highlighted in green in Appendix A) and the content of each of those documents was subsequently assessed in more detail. Summaries of the 26 relevant references are given in Appendix B.

Sections 2.2 to 2.4 describe the findings of the literature review in more detail:

- **Section 2.2** – The discussion of economic and societal impacts (qualitative aspects). This includes a broad introduction on how the success of many services (e.g. food and drink) is reliant on road transport with particular use of the TRN. Three key areas are addressed:
    - **Section 2.2.1** (Welfare and Gross Value Added) – Drawing the distinction between welfare and Gross Value Added (GVA).
    - **Section 2.2.2** (Importance of road transport) – Discussion of the importance of road transport to different business sectors.
    - **Section 2.2.3** (Inclusive growth including accessibility) – A series of international and local studies that demonstrate how road transport can alleviate poverty, promote inclusive growth, improve social cohesion and integration and the lack of road transport can act as a potential constraint for remote communities reliant on access to key services.
    - **Section 2.2.4** (Food, tourism and employment) – Describes the importance of the TRN for moving food and drink products, employment and the day visitor market for tourism.

- **Section 2.2.5** (Land use and property values) – Addresses the importance of transport improvements on land use values.

- **Section 2.3** – Discussion of quantitative economic assessment methods
  - **Sections 2.3.1** (GVA) – Summary of the GVA assessment method.
  - **Section 2.3.2** (Approaches to estimating GVA for other transport modes) – Description of the approach adopted in the Oxera (2016) study which valued the contribution of the rail industry to the Scottish economy.
  - **Section 2.3.3** (Case studies of the economic contribution of roads) – Case studies examining UK and international evidence.
- **Section 2.4** (Summary and selection of the economic method for this study) – Description of the approach adopted for the development of an economic model for the assessment of the benefits of the TRN.

2.2 Economic and societal impacts of the TRN (Qualitative Aspects)

2.2.1 Welfare and GVA

Economics is the study of how societies choose to produce and allocate goods and services under a system of scarce resources. Economic welfare is the total economic well-being of society. Although the level of welfare cannot be measured, it is possible to assess changes resulting from a project or policy. Cost-benefit analysis is based on the assessment of welfare benefits and costs, of which only some can be calculated in monetary terms.

A change in economic opportunity results from improvements in the form of greater use of inputs, expanded output or enhanced welfare (economic development). Transport projects in Scotland are appraised in a sustainable development framework where all projects must set out their environmental, economic, safety, accessibility and integration effects using Scottish Transport Appraisal Guidance (STAG). Appraisals estimate the social welfare benefits and costs of a scheme, relative to a 'Do Nothing' scenario. These welfare effects include journey time savings and reliability, and environmental factors.

GVA is the value generated by any unit engaged in production and the contribution of individual sectors or industries to a country's Gross Domestic Product (GDP). It represents the direct economic benefits of economic activity, whereas welfare involves wider aspects. Many welfare gains from transport schemes are themselves recorded as increases in GDP, but some are not. It is possible that some impacts on GDP do not reflect increases in welfare. Wider economic benefits are examined in transport appraisals where there is evidence of market failure such as agglomeration externalities, imperfect competition and the economic benefits of increased employment and productivity.

The social value of transport or a transport improvement was explored by Venables *et al.* (2014). This highlighted the importance of making a distinction between economic welfare and GDP. For example, road congestion could increase GDP (expenditure on fuel) but reduce welfare (increased journey time, higher emissions and noise). Double counting is also an issue in addressing the linkages between welfare and GDP. For example, the effect of

reduced commuting time due to a transport improvement would be calculated as a user benefit in terms of reduced generalised travel costs. However, this may be double counted in higher property prices and rents due to the transport improvement. Figure 1 presents some of the key interactions between welfare and GDP.

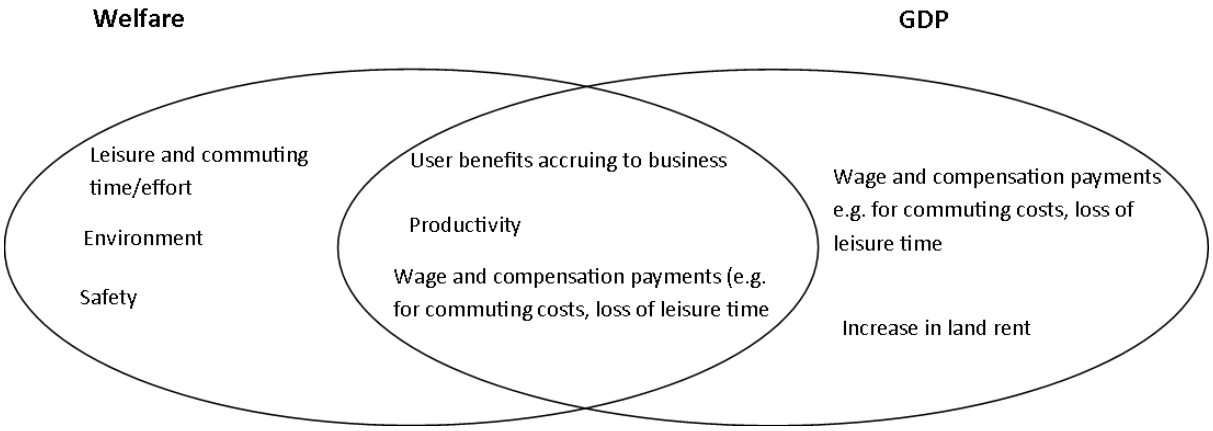


Figure 1 - Welfare and GDP measures (reproduced from Venables et al., 2014)

The valuation of either GDP or welfare requires the comparison of situations with the transport investment, and without it (the counterfactual). In determining whether an investment will lead to the creation of new jobs, this can only be valued if it is known what workers would have been doing in the absence of the improvement (Venables *et al*., 2014).

2.2.2 Importance of road transport

Economic analyses of road transport appraisals have commonly focused on direct impacts such as journey time savings, accessibility and traffic safety. Recently there has been increasing recognition of the need to include wider economic impacts, which are more challenging to quantify, but still important (Metsäranta *et al.*, 2014).

The World Road Association (2016) showed that the road network can deliver economic and social benefits to all sectors of the economy and be fundamental to the success of service sectors such as trade, health, education, tourism, agriculture, food and drink, and rural and urban development. In addition, it is recognised that the TRN can be used by a wide variety of vehicular modes: cars, taxis, lorries, vans, cycles, motorcycles, buses and coaches. However, heavily trafficked roads can also act as barriers to access for communities, particularly pedestrians with disabilities.

Road transport is crucial to the normal functioning of many sectors; Figure 2 reproduced from the World Road Association (2016) report showcases a selection of sectors where road transport is at the heart of the economy. It highlighted the importance of road maintenance to preserve the road asset – if adequate funding is not available to maintain the network then there will be a knock-on effect for many sectors of the economy such as tourism, manufacturing, trade and commerce.

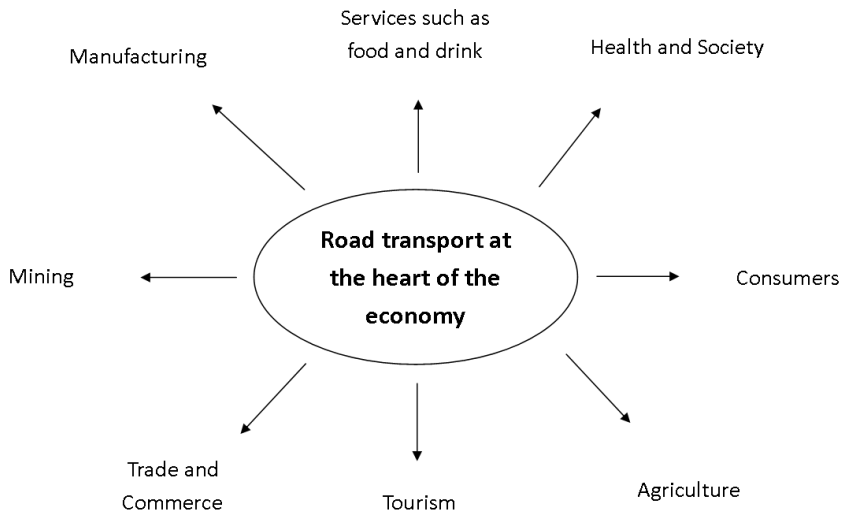


Figure 2 – Economic and social benefits provided by the road network (Adapted from World Road Association, 2016)

A summary of the qualitative aspects of economic and societal impacts found in the literature review are described in Sections 2.2.3 to 2.2.5.

2.2.3 Inclusive growth (including accessibility)

Inclusive growth is highlighted in the National Transport Strategy (Transport Scotland, 2016b) and Scotland's Economic Strategy (Scottish Government, 2015) as one of four broad priority areas. The Strategy sets out the mutually supportive pillars of increasing competitiveness and tackling inequality. Making growth more inclusive is important for enhancing Scotland's economic competitiveness, reducing wider inequalities, and improving opportunities for all. Inclusive growth can be defined as growth that reduces poverty and inequality, and benefits the most marginalised (CAFOD, 2014).

Scotland's Economic Strategy sets out ways to promote inclusive growth through:

- Fair work and the building of a labour market that provides sustainable and well-paid jobs
- Addressing barriers in the labour market for all sectors
- Tackling cross-generational inequality through improved child care and boosting attainment in early years
- Delivering equal growth and regional cohesion by capitalising on local knowledge and resources

The TRN plays a vital role in the promotion of all these requirements for inclusive growth within Scotland. This was also set out in The National Transport Strategy by Transport Scotland (2016b) with its five high level objectives:

- Promote economic growth
- Promote social inclusion

- Protect the environment and improve health
- Improve safety of journeys
- Improve integration

Inclusive growth is promoted by Scotland's TRN by combining increased prosperity with greater equity through improved access to education, jobs and services across Scotland. The TRN is used by buses, the prime mode of transport for many excluded and/or low income groups, including the elderly, job-seekers and people with disabilities. The TRN helps to tackle geographical inequality by improving accessibility to rural remote communities and enhancing regional cohesion.

Various studies have covered the socio-economic importance of road transport and the TRN. A study by the European Road Federation (ERF, 2001) highlighted the socio-economic benefits of road transport including impacts on economic welfare, public finances and social cohesion/integration. The linkages between road transport and upward social mobility were highlighted; for example, road transport reduces absolute poverty by improving economic efficiency due to decreases in costs and prices, the enhancement of trade and employment opportunities, and improved access to healthcare, education and other services. In summary, the ERF found that road networks like the TRN in Scotland can alleviate poverty, create/stimulate positive synergy, enhance social cohesion and integration, and promote inclusive growth by providing the same opportunities in social mobility to the entire population.

Parkman *et al.* (2012a), Parkman *et al.* (2012b) and Parkman and Bradbury (2012) all highlighted work by the Social Exclusion Unit (2003) which suggested that poor road transport links, including those provided by the TRN, can leave areas isolated and damage community cohesion.

Johansson (2006) cited a study undertaken by Halcrow, which investigated the concept of "lifeline" roads in Scotland as part of the Highlands and Islands Strategic Transport Partnership (HITRANS). This defined a "lifeline" road as "a transport link which has no substitute, or where the substitute entails a considerable increase in time or money expenditure, where any diminution in the quality, reliability or availability of the road, is likely to have a significant impact on the social or economic viability of an affected community".

The aim of the Halcrow study was to investigate the causal link between road condition and the socio-economic well-being of remote communities. Nine key roads that served areas of Highlands and Islands suffering from varying levels of economic and social deprivation were appraised using Scottish Transport Appraisal Guidance (STAG) and Transport Economic Efficiency (TEE). TEE, which is part of STAG, is used to estimate the welfare gain from transport investments. This is measured as the individual's willingness to pay for the improvement and the financial impacts on private sector transport operators (Transport Scotland, 2016c; Transport Scotland, 2016d).

The results of the study showed that several of the roads selected were considered to be insufficient to provide sustainable economic and social prosperity of the communities they served, and that an upgrade was required to provide long-term sustainability of the

communities. The proposed road schemes were also expected to contribute indirect benefits such as increased employment and improved accessibility to markets and customers.

In some cases, these roads provide the only means of access to and from remote regions in Scotland. This can marginalise groups of people such as people with disabilities, or those with reduced mobility, people with children and older people who may not have access to a car and rely on public transport. This places a significant constraint on the ease/comfort with which remote communities and marginalised groups of people can access "lifeline" services such as health, education, retailing and banking, many of which may be located in regional centres some distance away from rural communities.

The fragile nature of remote communities in Scotland is further accentuated by the lack of alternative routes when delays and closures occur on the TRN. For example, in the Argyll and Bute region, an event such as a landslip can result in a road closure and a long diversion. The quickest diversion for a closure on the A816 Oban to Lochgilphead added an extra 48 miles to the journey (Ekosgen, 2016). In addition, some alternative routes are not suitable for all vehicle types (e.g. HGVs and buses). For example, a closure on the Berriedale Braes section of the A9 in Caithness in 2014 due to a lorry fire resulted in a detour of over 80 miles which was deemed unsuitable for HGVs (BBC, 2014).

In another study conducted for HITRANS, McDowall and Adams (2008) developed a strategy for investment in key routes on the network to enhance the accessibility of rural communities. The first stage of the study reviewed the conditions and constraints of the locally significant road network. It was recognised that these "lifeline" roads in Scotland were in a poor condition and acted as a significant constraint to remote communities. In particular, the following factors were identified as affecting the quality of Scottish roads and therefore their value to rural communities:

- Poor road surface quality
- Poor road geometry and alignment
- Narrow roads with inadequate numbers of passing spaces
- High traffic volumes
- Slow average speeds

The second stage of the study assessed all the routes to identify those where interventions would best meet the objectives of the investment strategy that focused on serving the most fragile communities. The final stage was an assessment of socio-economic impacts for the interventions, which included a range of initiatives such as road widening, road realignment and construction of new footpaths. The social impacts identified are summarised as:

- Improved accessibility of key services to health, education and retailing and leisure
- Improved accessibility to employment by making it easier for residents in remote communities to travel to work in regional centres
- Maintained sustainability of fragile and remote communities

In a more recent study, Canning *et al*. (2015) researched the social and economic benefits of community transport in Scotland, which is dependent on the TRN. Community transport can be defined as a "wide range of transport solutions usually developed to cover a specifically identified transport need, typically run by the voluntary sector for the local community on a not-for-profit basis". The study involved a questionnaire-based survey of community transport users and in-depth interviews with the transport providers. Benefits to users were shown to include reducing transport accessibility poverty, promotion of inclusive growth and health benefits such as improved access to health services. Analysis within this study suggested that the 75 staff across the five community transport case studies generated £2.8 million GVA per annum.

2.2.4 Food, Tourism and Employment

The TRN plays a key role in supporting the movement of products and goods with the potential to open up access to new markets. For some products, such as fresh fish, the movement is time critical because of their perishable nature; therefore the reliability of the TRN is crucial (Ekosgen, 2016).

The HITRANS study undertaken by Halcrow which looked at the importance of "lifeline" roads to rural communities also included a business survey. That demonstrated the majority of companies served in The Highlands and Islands are heavily dependent on the TRN. The key results were:

- 75% of the businesses considered transportation of goods and supply to be very important for the business
- 50% of the firms expected a road scheme improvement to reduce the transport costs and allow increased turnover
- 33% of the firms considered that a road scheme improvement would allow them to expand the number of employees by 10% or more.

Transport on the TRN plays a key role in being able to recruit and attract people for employment as long and variable journey times can act as a barrier to travel to work. Road transport activities have direct and indirect effects on employment. Direct job creation is related to investment in road infrastructure, while indirect job creation is derived from the effect on the economy's competitiveness and productivity by road sector activities (ERF, 2001).

The TRN has a strong link to the tourism industry across Scotland. For example, Ekosgen (2016) noted that decreases in the quality of the transport infrastructure (through planned/known closures, unplanned closures or congestion on the TRN) can increase travel times and have a negative impact on the number of day or short duration visitors, potentially affecting the "impulse" tourist market. There could also be an impact on business visitors who may be less inclined to make as many business interactions/visits if they know that their journey is likely to be disrupted and hence too difficult to achieve in one business day (Ekosgen, 2016).

Recent research by Transport Scotland on how the Growth Sectors in the Scottish economy use the TRN, found that the Food and Drink sector is impacted by the road network at

several key points in the process. Delays in receipt of delivery of raw materials can cause production/processes to slow or even cease altogether, and delays to the despatch of products to end user markets have obvious cost implications. Additionally, a delay to the distribution of perishable goods, such as shellfish, reduces the amount of time that they are viable for sale, again with obvious financial implication for producers.

It is recognised that the impacts of the TRN extend beyond the actual road network. The TRN acts as a series of corridors that both attract users and enable users to access adjacent communities. Although this is difficult to quantify, there are clearly combined direct, indirect and induced outputs from the road network.

2.2.5 Land use and property values

Metsäranta *et al.* (2014) analysed the impact of road and rail transport on land use and property values. For example, investments in road junctions can act as a catalyst by influencing a wider geographic area through "agglomeration" effects. This increases the attractiveness of the location for companies and households due to improved accessibility, and influences the rent levels that companies are prepared to pay. This can, however, create pressures on land use planning and requires higher rates of land efficiency.

STAG (Transport Scotland, 2016e) provides guidance highlighting three specific economic/social impacts from investing in transport: agglomeration, output change in imperfect competitive markets and tax revenues arising from labour market impacts. These have all been recognised in the literature and tax revenues have been included in the economic analysis (see Section 3).

2.3 Economic and societal impacts of the TRN (Quantitative assessment methods)

Most quantitative transport appraisal techniques are based on a Cost Benefit Analysis (CBA). CBA is a systematic process for calculating and comparing the benefits and costs of a proposed project or investment. As noted above, CBA focuses primarily on quantifying the impact on economic welfare. It has two purposes:

1. To determine if it is a sound investment/decision (i.e. the justification for/ feasibility of the decision); and
2. To provide a basis for comparing projects. This involves comparing the total expected cost of each option against the total expected benefits, to see whether the benefits outweigh the costs, and by how much.

The benefit-cost ratio (BCR) summarises the overall value for money of an investment or proposal. The ratio is the benefits from the investment, expressed in monetary terms, relative to its costs (also expressed in monetary terms). The higher the BCR the better the investment.

STAG appraisals include non-quantifiable benefits from projects. However, it is not always possible to monetise all impacts and therefore non-monetised variables can sometimes be presented to complement the BCR.

Various methods for assessing the value of the TRN to the Scottish economy could be adopted, each having strengths and weaknesses. STAG and WebTAG contain some analysis tools for estimating wider economic benefits:

- STAG (Transport Scotland, 2016e) provides a clear and robust framework to identify and appraise the impacts of potential transport interventions and investments. It is objective-led rather than solution-led in order to avoid pre-conceived solutions being brought forward without considering other options which may better meet the identified problem or opportunity.
- WebTAG (Department for Transport, 2016a) is the Department for Transport (DfT) appraisal guidance and toolkit. It consists of software tools and guidance on transport modelling and appraisal methods that are applicable for transport interventions.

More details can be found in Appendix C, which also contains a brief summary of how a Transport Business Case (TBC) can be used.

The approach adopted in this study for assessing the impact of the TRN on the Scottish economy has used a combination of both quantitative and qualitative indicators. Since this project was concerned with assessing the value of the whole existing TRN network to the economy and society rather than the costs and benefits of a specific intervention, the approach adopted has been to quantify GVA of the whole TRN.

2.3.1 GVA (Gross Value Added)

ONS (2015a) defines GVA as the value generated by any unit engaged in the production and the contribution of individual sectors or industries to GDP.

GVA plus taxes (less subsidies) on products is equivalent to GDP. Regional estimates of GVA are usually measured using the income approach, summing income generated by resident individuals or corporations in the production of goods and services[2]. Total GVA estimates are divided by the resident population to calculate per capita GVA. This can be useful for comparing regions of different sizes, provided there are no large commuting flows into or out of the regions.

GVA can also be applied to understand the contribution of different economic sectors. Some components of GVA include Gross Trading Profits and Surplus, estimates of total Gross Operating Surplus and rental income (ONS, 2016).

These components are summed to form estimates of GVA. Undertaking a full and complete GVA approach requires significant data input. Much of the data should be available in Scotland, at least for a scaled down version of GVA, although it may not be at the appropriate level of disaggregation, especially for components such as TRN construction and maintenance or freight distribution directly using part of the overall road network.

[2] Scotland is usually designated as a region of the UK although GVA could be measured at the 'sub-Scotland' level, if sufficiently disaggregated data is available. Alternative estimates of GVA are measured using the production approach, with the effect of inflation removed.

GVA calculations are generally more appropriate for sectoral analysis (e.g. construction or freight distribution) than the specific impact of the TRN network on the wider economy. The Oxera approach for the rail sector included a GVA estimate of the impact of that sector. This could be undertaken more easily for the rail sector than for roads due to the availability of data on the rail sector that is not disaggregated for the TRN or even for highway construction and maintenance for the road network.

2.3.2 Approaches to estimating GVA for other transport modes

Oxera (2016) investigated the economic footprint of the rail sector in Scotland and identified two types of impact:

- **Direct** – measures the economic value of activities and outputs of the railway industry (i.e. the resources used to deliver rail services, including employment); and
- **Indirect** – measures the economic value of resources to the domestic supply chain (i.e. within Scotland) used by the rail industry to undertake its activities.

Oxera applied an approach that comprised three main indicators to estimate the contribution of the sector to the Scottish economy:

- **GVA** - an approximate measure of the increase in the value of the economy due to the production of goods and services. The GVA of the rail sector in Scotland was estimated by Oxera to be £668m per year in 2014/2015.
- **Employment** – the number of employees (full-time equivalent) in the rail sector, including suppliers as well as Train Operating Companies etc. Oxera showed that around 12,800 people were employed by the rail sector.
- **Tax receipts** – from income tax (via PAYE), Corporation Tax, National Insurance Contributions but less Value Added Tax (VAT). Tax receipts from the rail industry were estimated to be £292m.

User benefits were estimated based on three counterfactual scenarios against the status quo: when passenger and freight volumes were reduced by 10%, 50% and 100% (i.e. absence of the rail network) respectively. This calculation was designed to demonstrate the economic footprint of the rail sector. If the rail sector was smaller and the resources currently used by it were redeployed to equally productive use elsewhere in the economy, there would be no economic benefit from the rail sector. The impact of these reductions generates a range of impacts of between £101m (from a 10% reduction in the rail sector) and £1,014m (from a 100% reduction), of which 94% were reduced passenger benefits.

Wider economic benefits (spill-over benefits), for example economies of agglomeration, congestion reduction and modal shift to road from rail, were also calculated at between £64m and £652m per year. Environmental and social benefits, such as the value of reductions in Greenhouse Gas emissions, were estimated by Oxera to be between £3m and £30m per year. These calculations provide an overall estimate of the contribution of the rail sector to the Scottish economy.

It should be noted that the rail sector is a relatively self-contained transport system whereas the TRN forms part of a much more extensive road network.

The scope of this project required an estimate of GVA resulting from the TRN. GVA was applied by Oxera and it was recognised that it would be beneficial to adopt a similar process, to the extent that the available data allows, and to enable a comparison between the economic impact of the TRN and the rail sector to be made (albeit with appropriate caveats). Different approaches to the calculation of GVA are possible, of which the income approach is the most common. As outlined earlier, a range of other sources of income could be included but for these it would be extremely difficult to assemble the data relevant to the TRN in Scotland. As a result, the GVA calculated in this study is likely to be underestimated.

2.3.3 Case Studies of the economic contribution of roads

International Evidence

Ernst & Young (2010) analysed the economic impact of road investments in road infrastructure within the metropolitan and outer metropolitan regions of Victoria in Australia between 1996 and 2008. This was conducted by a cost-benefit analysis, which was derived from

- **Capital and operating costs of the road network** – Capital costs included land acquisition costs, pre-construction costs, non-construction costs, construction costs and risk.
- **Vehicle operating costs** – Parameters were used from Austroads (2008)[3] and traffic outputs such as road type, speed and vehicle type.
- **Travel time costs** – Parameters were used from Austroads (2008) and cost outcomes were then calculated using aggregates of traffic vehicle class, route distance, average occupancy and value of time per occupant.
- **Road accident costs** – Parameters were used from Austroads (2008) (e.g. urban crash and accident information).
- **Environmental costs and benefits** – Impacts such as climate change, noise, urban separation, water and nature/landscape were evaluated
- **Wider economic benefits** – Agglomeration, increased competition, imperfect competition, economic welfare benefits arising from improved labour supply and economies of scale
- **Economic contribution analysis** – Using a Computable General Equilibrium (CGE) model

In addition, a transport appraisal approach from the UK Department for Transport was used by Byett *et al.* (2015) in New Zealand. A GDP model against various measures of accessibility was chosen and produced a range of GDP estimates (from NZ$246.1 million to NZ$530.4

[3] Austroads (2008) has assembled knowledge on project evaluation methods, parameters and tools into a readily available and accessible resource for planners and decision-makers. The guide provides advice to practitioners beyond the standard benefit-cost analysis (BCA) including project risk assessment, the national and regional impacts of projects, distributional (equity) effects of projects, and project post-evaluation analysis.

million) and demonstrated productivity gains from local agglomeration, as well as from wider connectivity.

UK Evidence

Transport Scotland (2016d and 2016e) produced a Strategic and Socio-Economic investment case for the dualling of a section of the A9, the longest trunk road in Scotland. The Scottish Government intends to dual an 80-mile section between Perth and Inverness where road users have frequently experienced slow and inconsistent journeys. This stretch of road has a history of incidents causing long diversions/delays and safety concerns due to a higher than average rate of serious and fatal accidents.

The socio-economic case addressed the following points over the 60 year appraisal period:

- Environment – A Strategic Environmental Assessment (SEA) was undertaken
- Air quality – The predicted increase in travel speeds due to dualling of the A9 will result in additional fuel use and increases in CO_2 emissions. It was estimated that the value of CO_2 emissions would result in disbenefits of around £50 million.
- Safety – Significant improvements to road safety were expected with estimated benefits of £343.8 million. Local accident occurrence and severity rates were analysed with accidents tending to be more serious in nature, thus more costly in economic terms
- Economy – User benefits were estimated at £1,045 million (in 2010 value and prices) using a Transport Economy Efficiency (TEE) analysis. Significant benefits, such as journey time savings due to higher road speeds were offset by increased vehicle operating costs and increased fuel consumption
- Wider Economic Impacts – Benefits were estimated at £210 million by taking into account the improved connectivity between businesses and wider labour markets
- Transport Integration – Improved journey times will likely improve the reliability of public transport and aid freight movements for more efficient transportation of goods
- Accessibility and social inclusion – Improved accessibility and the provision of high quality lay-bys to aid wider access for communities and to support tourism in the local area

As part of the economic case, it was demonstrated that substantial benefits would be provided by the proposed improvement to convert the A9 to dual carriageway. The monetised value of benefits did not include Wider Economic Benefits, which were included in an additional sensitivity test.

Parsons Brinckerhoff (2012) carried out an economic impact study for improving the full length of the A303/A30 between Amesbury and Honiton, and the A358 between Ilminster and Taunton (both major routes in the South West of England) by converting them to dual carriageways. This included an analysis of the Transport Economic Efficiency and the Wider Economic Impacts, which were considered independently:

- Transport Economic Efficiency – Used the DfT WebTAG and Cost Benefit Analysis (COBA) software.
- Wider Economic Impacts – Used the DfT appraisal guidance and GVA to analyse the impact of the scheme on the economy in the South West.

The project identified benefits through the assessment of transport and wider economic impacts, both quantitatively and qualitatively.

Arup (2014) developed a Transport Business Case (TBC) which assessed the strategic, economic, commercial, financial and management cases for the construction of a new section of three-lane motorway in the M4 corridor around Newport, Wales. The study included the wider economic impacts of the new road: agglomeration, output change in imperfectly competitive markets and labour supply impacts.

The wider economic impacts had a Net Present Value of £715.8 million over the 60 year appraisal period. This represented an uplift of 37% on the user benefits from the first part of the economic appraisal with the majority of effects related to agglomeration (see Table 1).

Table 1. Summary of wider economic benefits for the M4 corridor, Newport, Wales* (reproduced from Arup (2014))

Wider Impact	Net Present Value (Discounted)
Agglomeration	£562.7 million
Output in imperfectly competitive markets	£130 million
Labour supply impact	£23.1 million
Total	**£715.8 million**

* Discounted benefits over a 60 years appraisal period

2.4 Summary and selection of economic method for this study

In summary the review has indicated that:

- None of the individual economic appraisal methods considered has the ability to address the TRN on a network-wide basis – they appraise project proposals;
- A combination of indicators was considered to be the most appropriate approach to assess the value of the TRN to the Scottish economy and to provide a good description of the economic impacts of the TRN;
- Data availability for the TRN in Scotland is limited so some assumptions are needed;
- Counterfactuals may be applied but in practice, significantly reducing the size of the TRN is unlikely to occur and so may not be appropriate. Nevertheless, this approach offered the best way to assess the benefits;

- The approach to calculating GVA is consistent with the Oxera approach for the analysis of the rail network;
- Robust estimates of the economic impacts of the TRN in Scotland could be generated.

In transport economics, assessment and appraisal methods have been developed to estimate the benefits of changes to the existing networks; they have not however been developed to assess the overall benefits of a complete transport network such as the TRN in Scotland. Valuing the contribution of all roads is challenging compared to the rail network, which is a self-contained network. The road network is an integrated system made up of the TRN and local roads, and it is complex to isolate the benefits of the TRN from the benefits from the other parts of the road network.

In assessing the potential economic evaluation options for the benefits of the TRN, several criteria have been considered:

- Ability to address the TRN on a network-wide basis
- Coverage of economic impacts (e.g. journey time reductions; lower costs of freight distribution; agglomeration benefits; reductions in road traffic accidents; air quality impacts and carbon emissions; improved access opportunities for isolated communities);
- Data requirements and availability
- Counterfactuals
- Comparability, compatibility, consistency and complementarity with the Oxera approach.

In order to develop an approach that demonstrates the importance of the TRN in Scotland, the general Oxera approach has been applied and this has involved gathering a variety of data to measure a range of impacts of the TRN such as aGVA, tax revenues, Road Traffic Accidents (RTA), travel time and greenhouse gas emissions. Non-quantifiable impacts of the TRN have also been identified. These include wider economic impacts, such as agglomeration externalities, imperfect competition, the economic benefits of increased employment and productivity, and accessibility. More details are provided in Section 3.3.

3 Modelling the Value of the Trunk Road Network to Society and the Economy

Section 3.1 provides a summary of the methodology used for assessing the economic and societal impacts of the TRN in Scotland. Section 3.2 describes the assumptions and results of the base case analysis undertaken in this study. Section 3.3 provides a qualitative analysis of the impacts that were not quantifiable

3.1 Methodology

The Value of the Trunk Road Network (TRN) to Society and the Economy (VaTSE) model has been developed to calculate the economic impact of the TRN in Scotland. It is based on calculations of six aspects of the analysis:

- aGVA (approximate Gross Value Added)[4] of the Freight, Public Transport (PT) and Construction and Maintenance (C&M) sectors
- Per capita aGVA for the Freight, PT and C&M sectors (calculated from the total aGVA)
- Tax receipts of the Freight, PT and C&M sectors
- Road Traffic Accidents (RTAs) from the use of the TRN compared to the same traffic on non-TRN roads
- Travel time using the TRN compared to redistributed TRN traffic on non-TRN roads
- CO_2 emissions of using the TRN compared to redistributed TRN traffic on non-TRN roads

In the model, there is a worksheet for each aspect of the analysis. A separate worksheet is used for traffic flows that feed into the RTA, travel time and CO_2 calculations. A summary worksheet shows the results from all the calculations.

For the analysis approach, where possible, published data has been used from Transport Scotland and other UK Government departments. Where necessary, where there was no data available that specifically relates to activities involving the provision/use of the TRN in Scotland, assumptions were made, using other data to represent the effects of the TRN.

Snapshots of the model worksheets are presented in Appendix D. Each worksheet within the model contains details of the data sources and assumptions, which can be found in Appendix E, and examples of existing data that can help identify the data needed for analyses.

For the analyses of aGVA, tax receipts and per capita aGVA, the three sub-sectors that directly contribute to or benefit from the TRN in Scotland are considered in the model:

[4] Calculation of aGVA follows SABS methodology – this is based on data from Annual Business Survey (ABS) conducted by the Office for National Statistics (ONS). Within SABS, estimates by industry sectors are published for Scotland and expressed as monetary values (Scottish Government, 2016b)

- Freight
- Public Transport (PT)
- Construction and Maintenance (C&M)

In selecting these sectors, both providers and users of the services and opportunities offered by the TRN have been chosen. The main providers of the network are those engaged in the construction and maintenance of the network. The main economic users are freight operators and public transport. In addition it is recognised that many other sectors use the TRN for economic purposes. These include both car commuters as well as those driving on the TRN on business. In both cases the TRN improves access to a range of opportunities. Since commuters are not actually working while they are travelling this group has been excluded from the aGVA calculations. As a result the economic impact of the TRN, as indicated by the aGVA calculations, is likely to be greater than the estimate.

3.1.1 Employment

The employment figures for Freight, PT and C&M for Scotland's TRN are calculated as a percentage of the total employment in each sector in Scotland and the percentage employed on the TRN. These derived TRN employment figures are used in the aGVA, per capita aGVA and tax receipts calculations (see Sections 3.1.2 to 3.1.4)

3.1.2 aGVA

aGVA is calculated individually for Freight, C&M and PT using the GVA per head for each sector and the employment values in Equation 1. The totals for all three sectors are then summed to provide a total figure for aGVA.

Equation 1 – aGVA

$$aGVA = (GVA\ per\ head\ *\ Total\ employment\ on\ the\ TRN)$$

3.1.3 Per capita aGVA

The aGVA calculation uses the aGVA per head for each sector (Freight, PT and C&M) but this worksheet provides a comparison of those values based on the same levels of employment and the total aGVA for each of the three sectors.

The per capita aGVA is calculated individually for Freight, C&M and PT using Equation 2 and combined to give the total aGVA.

Equation 2 – Per capita aGVA per sector

$$Per\ capita\ aGVA\ = aGVA \div Total\ Employment$$

3.1.4 Tax receipts

Employees and companies involved in the provision and use of the TRN contribute to the economy via taxation. In the model, the three areas of tax analysed, and the proxies used to calculate their proportions for the three sectors of Freight, PT and C&M are:

- PAYE – Proxy: Compensation of Employees
- Corporation Tax – Proxy: Gross Operating Surplus
- VAT – Proxy: Total GVA

The total employment for each sector is then used to estimate the tax receipts. Note, the employment numbers used in each sector may differ from the employment numbers used for aGVA because the tax data represents different parts of the total employment in each sector.

The percentage of the employment in each sector employed on the TRN is taken from the aGVA worksheet.

The same calculation methodology is used for PAYE, Corporation tax and VAT for the three sectors.

The three stages in the calculation of the tax receipts from each of the tax areas are shown by Equation 3, Equation 4 and Equation 5. Note that 'tax proxy' in the equations refers to PAYE, Corporation tax or VAT.

Equation 3 – Tax proxy for the sector

$$Tax\ proxy\ for\ the\ sector = \frac{Compensation, surplus\ or\ GVA\ for\ the\ sector\ * Total\ tax\ proxy\ for\ Scotland}{Compensation, surplus\ or\ GVA\ for\ all\ Scotland}$$

Equation 4 – Tax proxy per employee for the sector

$$Tax\ proxy\ per\ employee\ for\ the\ sector = \frac{Tax\ proxy\ for\ the\ sector}{Total\ employment\ for\ the\ sector}$$

Equation 5 – Tax proxy for the sector

$$Tax\ proxy\ for\ the\ sector = Tax\ proxy\ per\ employee\ for\ the\ sector * Employment\ on\ the\ TRN\ for\ the\ sector$$

The total tax receipts are calculated using Equation 6 for Freight, PT and C&M, and summed to generate the total tax generated.

Equation 6 – Total tax receipts

$$Total\ Tax\ Receipts\ for\ the\ sector = PAYE + Corporation\ Tax + VAT$$

3.1.5 Traffic

Traffic values are input in terms of million vehicle kilometres, split by road type (i.e. Motorways, Trunk 'A' roads (urban and rural), Non-Trunk 'A' roads (urban and rural) and Minor roads (urban and rural)) and vehicle type (i.e. Cars, 2-wheeled motor vehicles, Buses, Light Goods Vehicles and Heavy Goods Vehicles). The traffic levels are used in the calculations of RTAs, travel time and CO_2 emission as described in Sections 3.1.6 to 3.1.8.

The calculations of the impacts on the RTAs, travel time and CO_2 emissions use the redistribution of the TRN traffic on to the non-TRN roads. The percentage of the traffic on each of the TRN road types to be carried by each non-TRN road type is specified by the user. Note, the redistribution of the TRN traffic to the non-TRN roads may be more or less than 100% if it is assumed there will be a change in the distance travelled by the TRN traffic when the TRN is not available. The percentages for the redistribution are the same for all vehicle types.

3.1.6 RTAs

The benefit from reduced RTAs is calculated as the difference between the RTAs assuming the current use of the TRN and the RTAs if the TRN traffic is redistributed on to non-TRN roads using the number of fatal and serious accidents and their respective costs.

The extra costs of accidents for the redistributed TRN traffic are calculated using the accident costs per vehicle kilometre for the non-TRN (see Equation 7).

Equation 7 – Total cost of RTAs by road type per million vehicle kilometres

$$Total\ cost\ of\ RTAs\ by\ road\ type = \frac{No.\ of\ accidents\ (by\ road\ type) * Cost\ of\ accidents\ (by\ road\ type)}{Traffic\ (by\ road\ type)}$$

3.1.7 Travel time

The benefit from reduced travel times is calculated as the difference between the journey times assuming the current use of the TRN and the journey times if the TRN traffic was redistributed on to non-TRN roads using the traffic data from the traffic worksheet. Average speeds for each vehicle type on each road type are input by the user together with the value of time for each vehicle type. Four separate calculations are carried out for the time savings:

- Proportions of traffic for each road type and vehicle type
- Journey times on each road type and vehicle type for TRN traffic on the TRN and when redistributed to the non-TRN roads
- Differences in the journey time for the TRN traffic (before and after redistribution)
- Total cost of the increased journey time for each vehicle type

Equation 8 is used to calculate the total journey time.

Equations 9 and 10 are used to calculate the delay time and delay cost by vehicle type.

Equation 8 – Total journey time

$$Total\ journey\ time =$$
$$Traffic\ in\ million\ vehicle\ km\ (by\ road\ type)\ /\ average\ speed\ (by\ road\ type)$$

Equation 9 – Total delay time

$$Total\ delay\ time\ (in\ million\ hours =$$
$$Total\ journey\ time\ of\ redistributed\ TRN\ traffic\ (by\ vehicle\ type)$$
$$-\ (minus)\ Total\ journey\ time\ of\ TRN\ traffic\ on\ the\ TRN\ (by\ vehicle\ type)$$

Equation 10 – Delay cost

$$Total\ delay\ cost\ (£\ million) =$$
$$Total\ delay\ time\ (by\ vehicle\ type) * Value\ of\ time(by\ vehicle\ type)$$

3.1.8 CO_2 emissions

The changes in CO_2 emissions are calculated by the difference between the emissions from the current use of the TRN (using the traffic flows from the traffic worksheet) and redistributed TRN traffic on the non-TRN roads.

The calculations use emissions data for Motorways, All urban roads and All rural roads. It is recognised that the emissions on non-TRN roads are higher (per vehicle kilometre) than on TRN roads and ratios are input for urban and rural roads to represent that increase.

The total emission from the TRN traffic is calculated per vehicle kilometre before and after that traffic is redistributed. The difference in the emissions is the benefit from the TRN from reduced emissions.

The emissions use the input CO_2 cost to value the change in the emissions.

The calculations use Equations 11, 12 and 13.

Equation 11 – TRN emissions for urban/rural

$$TRN\ emissions\ (urban\ or\ rural) = \frac{Road\ emissions\ (urban\ or\ rural)}{Trunk\ A\ road\ traffic + (Ratio\ of\ non\ TRN\ emissions * non\ TRN\ traffic)}$$

Equation 12 – Non-TRN emissions for urban/rural

$$Non\ TRN\ emissions\ (urban\ or\ rural) = TRN\ emissions\ (urban\ or\ rural) * Ratio\ of\ emissions\ between\ non\ TRN\ and\ TRN\ (urban\ or\ rural)$$

Equation 13 – CO_2 emissions cost

$$CO2\ emissions\ cost = CO2\ emissions\ by\ road\ type * Traffic\ per\ road\ type * Non\ traded\ CO2\ value$$

3.2 Base Case Analysis

For this study, a base case analysis was carried out using the VaTSE model to demonstrate the economic impact of the TRN in Scotland. Sections 3.2.1 to 3.2.8 provide a summary of each stage of the base case analysis.

3.2.1 Direct employment

The level of employment resulting directly from the TRN has been calculated both for providers of the TRN (C&M) and significant users (Freight and PT). This was estimated to be **31,361**, which is **1.2%**[5] of all employment in Scotland. By comparison, the rail sector employs up to 13,000 people.

In addition to the direct employment from the TRN, it should be noted that the TRN performs an essential service for commuters travelling to and from their place of work. This figure was estimated to be nearly 670,000[6].

Inter-urban routes and key trunk roads have significant percentages (often exceeding 50%) of morning peak traffic comprising long distance commuter traffic (Barker and Connolly, 2006). According to the 2001 Census approximately one quarter (23%) of Scottish workers

[5] 1.2% calculated using total employment in Scotland from Scottish Government (2016a) Monthly Economic Brief for October 2016

[6] 69% of workers drive to/from work based on 2011 census (National Records of Scotland, 2011) and the TRN carries approximately 37% of the total car traffic (Transport Scotland, 2016g). Therefore, based on the total employment in Scotland from Scottish Government (2016a), an estimate of commuters using the TRN is:

2,618,000 * 0.69 * 0.37 = 668,375

were long distance commuters (long distance commuting involves a single journey over 15km), of whom four-fifths (80%) travelled by car, probably including use of the TRN, at least for part of their journey (Barker and Connolly, 2006). The TRN is therefore likely to be particularly important for long-distance car commuters.

3.2.2 aGVA

The following assumptions were made for the base case analysis:

- GVA per head for "Land Transport and Transport via Pipelines" was used for both Freight and PT, and GVA per head for "Civil Engineering" was used for C&M. Data was sourced from SABS (2016)
- The total employment number for Freight was set at 37,000 as a result of a road freight analysis carried out by Transport Scotland in 2013
- The percentage of freight employment applicable to the TRN was set at 66% to reflect the percentage of total HGV vehicle kilometres on the TRN in 2014
- The total employment number for PT was set at 18,300 based on information supplied by Transport Scotland. This figure was derived from 2010/11 but was deemed acceptable based on work by the Department for Transport (2016b) showing the number of staff employed by local bus operators for Scotland has not changed between 2010/11 and 2015/16.
- The percentage of PT employment applicable for the TRN was set at 27% to reflect the bus traffic on the TRN in 2014
- The percentage of C&M employment was set manually at 13.245% to produce a total employment value of 2,000 for the TRN. The value of 2,000 was based on two figures:
    - 1,300 from BEAR for the operating companies (Transport Scotland, 2016f)
    - 700 from a weighted value of UK wide employment for construction of roads and motorways for Scotland (Standard Industrial Classification (SIC) code 42.11) using the traffic share and network length (Transport Scotland, 2016g)

The values used in the base case analysis are represented by the yellow input data in the screenshots of the model in Appendix D. Further details of data sources can be found in Appendix E.

For the base case analysis, the estimate of the total direct aGVA[7] is **£1.38 billion per year**. By comparison, the total GVA for Scotland in 2013 has been estimated as **£123.5 billion per year**[8] so the TRN in Scotland can be estimated to contribute about **1.1%** of the GVA for Scotland.

The aGVA figure is based on the TRN-related impacts of the Freight, PT and C&M sectors. The calculation is likely to understate the importance of the TRN by ignoring the benefits of

[7] Due to statistical uncertainties, the calculations of GVA are usually referred to as approximate (i.e. aGVA), a practice followed in this report. Where GVA terminology was quoted or referred to in other documents, the original use of GVA has been retained.

[8] 2013 GVA values from ONS (2015b) "Regional gross value added (income approach): December 2015"

the TRN to other sectors of the economy (for example vehicle manufacturing, fuel sales, retail sales and other impacts on the construction sector). Investments in the TRN will generate both direct and indirect effects but the wider economic impacts are difficult to measure quantitatively. Multiplier[9] effects arising from investments in the TRN will affect a wide range of economic activities in Scotland.

The contribution of the TRN to tax receipts has been calculated independently (see Section 3.1.4).

Some studies have also included the following data in the calculation of aGVA:

- Taxation gains and welfare payment savings from employment generation
- Disposable income multiplier impacts from employment generation
- The combined impacts from tourism
- The uplift in land values with the resultant Government tax gain from transport infrastructure investment.

Including these in the calculation would significantly increase the total direct aGVA, perhaps by as much as 1/3, given that multipliers from investments are typically calculated to be around 1.3 (although it must be recognised that the research evidence for the multiplier impact of transport investments in Scotland is sparse).

The estimated aGVA for the base case analysis is approximately twice the estimated value of the contribution of the rail sector GVA in Scotland (£668 million per year, Oxera 2016). The TRN is more extensive than the rail network – the rail network is 2,759 km long, of which 672 km has been electrified (Scottish Government, 2010). This compares to the length of the TRN of 3,570 km (i.e. 30% longer than the rail network). Further emphasis of the importance of the TRN in Scotland is that 44.8 billion vehicle kilometres are driven in Scotland each year with 38% on the TRN despite it representing only 6% of the total road network (Transport Scotland, 2015b). The TRN only comprises higher quality roads whereas the data for the rail network includes both mainlines as well as minor and under-utilised routes.

3.2.3 Per capita aGVA

Data sources and assumptions for per capita aGVA relate back to the aGVA calculation described in Section 3.2.2 and which can be found in Appendix E.

Based on data from 2014, per capita aGVA has been calculated as approximately **£44,000 per year**. This is marginally below the Scottish average of approximately £49,000 aGVA per capita for 2014 (SABS – excluding financial sector).

For the analysis undertaken in this project, the model does not calculate a new per capita aGVA value but rather, provides a check for the GVA per head values obtained from SABS

[9] An economic multiplier measures how much an endogenous variable changes in response to a change in some exogenous variable.

(2016) for each sector. Per capita aGVA for the C&M sector is very high, **£75,877 per year**, possibly due to the relatively high pay of civil engineers. In the Freight and PT sectors, the per capita aGVA is estimated as **£41,829 per year**. The main PT beneficiaries of the TRN in Scotland will tend to be the coach companies, rather than bus operators except in some urban areas; coach drivers tend to earn more than their bus counterparts.

3.2.4 Tax receipts

The following assumptions were made for the base case analysis:

- The total tax receipts excludes the tax paid by employees in other industries that benefit from the TRN and land taxes that may increase as a result of rises in property taxes such as business rates.
- Tax receipts accrued in Scotland are not broken down by sector, so the three proxies used for the calculations (see Section 3.1.4) were taken from Scottish Government Input-Output (I/O) tables and used to estimate the share of tax from each sector. I/O tables provide a complete overview of the flow of products in the Scottish onshore economy for a given year (Scottish Government, 2016c).
- I/O tables were used rather than SABS. Although SABS is appropriate for estimating the aGVA from an individual sector, unlike I/O tables it does not cover the entire economy (the financial sector is excluded). SABS data could not therefore be used to estimate the share of the tax receipts from the whole economy arising from each sector.
- Since Freight, PT and C&M are not identified as sectors within the I/O tables, data for SIC code 49 "Land Transport and Transport via Pipelines" was considered the closest match for Freight & PT and data for SIC code 41-43 "Construction" was considered the closest match for C&M.
- For each of the two SIC codes described above, a tax contribution per employee value was calculated for each of PAYE, Corporation Tax and VAT, using the three proxies. The per employee value was then applied to the TRN employment estimates for Freight, PT and C&M, to estimate the tax contribution from each sector;
- For PAYE, the percentage share of the total compensation of employees in Scotland generated by employment within SIC code 49 was calculated and applied to the total PAYE receipts for Scotland (GERS, 2016). This value was divided by the SIC code 49 employment to derive a PAYE per employee value. This per employee value was then applied to both Freight and PT employment estimates to calculate the PAYE receipts for each sector. The same approach was taken for C&M, but using data for SIC code 41-43.
- For Corporation Tax, the same methodology as outlined above was used, but using gross operating surplus data as a proxy.
- For VAT, the same method as outlined for PAYE was used, but using GVA data.

The values used in the base case analysis are represented by the yellow input data in the screenshots of the model in Appendix D. Further details of data sources can be found in Appendix E.

The estimated tax receipts (from PAYE, Corporation Tax and VAT) generated by the TRN have been estimated at **£358 million per year**. This compares to the tax receipts from the railway network of up to £290 million for 2014/15 from Oxera (2016). Over **90%** of the tax generated in the base case analysis is from PAYE and VAT.

3.2.5 Traffic

The traffic values from Transport Scotland (2016g) were used for the base case analysis and fed into the RTAs, travel time and CO_2 emission calculations, which were based on the TRN traffic moving to the non-TRN. The redistribution was based on the percentages provided in Table 2. Note that that the totals do not have to add up to 100% and a warning is provided in the model. However, for the base case analysis, 100% of TRN traffic is redistributed on to non-TRN roads.

Table 2. Redistribution (%) of TRN traffic on to non-TRN roads for RTAs, travel time and CO_2 emission calculations

TRN	Non-TRN				
	Non-TRN 'A' Urban	Non-TRN 'A' Rural	Minor urban	Minor rural	Total
Motorway	50	50	0	0	100
TRN 'A' Urban	95		5		100
TRN 'A' Rural		95		5	100

3.2.6 RTAs

The following assumptions were made for the base case analysis:

- 100% of the TRN traffic was redistributed on to the non-TRN roads. The split between different non-TRN road types is shown in Table 2 and also applies for the time savings and CO_2 emission calculations.
- The values for the cost of fatal and serious accidents were given by Transport Scotland (2014a). These were the most recent values available.

The values used in the base case analysis are represented by the yellow input data in the screenshots of the model in Appendix D. Further details of data sources can be found in Appendix E.

Estimates of the reported annual casualties for 2013/14 in Scotland by Transport Scotland (2014) were used in the model for the cost of fatal accidents (£1,990,632) and the cost of serious accidents (£230,156). The analysis shows that the redistribution of traffic from the TRN to the non-TRN would increase the cost of RTAs by **£171 million per year** with **£40 million** attributed to fatal and **£131 million** to serious accidents.

3.2.7 *Travel time*

The following assumptions were made for the base case analysis:

- It was assumed that 100% of the TRN traffic was redistributed on to non-TRN roads. The same percentage redistributions were used for all vehicle types. The split between different non-TRN road types is shown in Table 2.
- The free flow traffic speeds in Table 3 were used to calculate the difference in journey time between the TRN and redistributed TRN traffic on to non-TRN roads. It has been assumed there is no change in the traffic speeds caused by the extra traffic on the non-TRN.
- WebTAG average values for time per vehicle type were used for the analysis.

The values used in the base case analysis are represented by the yellow input data in the screenshots of the model in Appendix D. Further details of data sources can be found in Appendix E.

Table 3. Free flow traffic speeds (km/h) for each road type and vehicle type

Road Type	Cars	Two wheeled motor vehicles	Buses	Light goods vehicles	Heavy goods vehicles
Motorways	112	112	96	96	88
Trunk 'A' roads - Urban	80	80	48	48	48
Trunk 'A' roads - Rural	96	96	64	64	80
Non-trunk 'A' roads - Urban	48	48	40	40	40
Non-trunk 'A' roads - Rural	80	80	48	48	48
Minor roads - Urban	48	48	32	48	32
Minor roads - Rural	64	64	48	64	40

Travel times were calculated between the current use of the TRN compared to the redistribution of TRN traffic to non-TRN roads. The total increased travel time cost for use of the non-TRN, and therefore the benefit of the TRN, was calculated as **£1.64 billion per year**.

In some circumstances it is likely that some journeys would not be undertaken or might occur at different times of the day (e.g. off-peak rather than during the peak period). Due to the uncertainty/paucity of data, this has not been reflected in the analysis.

Journey time savings and increased reliability for business travel contribute to GDP and faster and more reliable journeys for work represent a productivity gain. Business time savings therefore increase GDP as well as welfare – a firm values the welfare gain because of the commercial advantage and higher productivity that results.

One part of the benefits delivered by transport improvements, including highway investments, is normally in the form of time savings to travellers. In transport appraisals,

time savings are calculated by measuring the willingness of users to pay[10] for the shorter time. For travel outside of work, including commuting, this is the value that travellers put on their time. For travel in the course of work, this is the value the firm puts on their employees' time (i.e. the gross salary costs).

In this way, the direct time savings is a subset of transport's contribution to economic development. These direct benefits to users are sometimes transferred to others. The time savings to firms will lead them to reduce prices and increase output, passing on benefits as reduced costs of its products. Time savings for commuters (and others) can increase the attractiveness of an area so that benefits are passed on to house and land owners. In this way, the direct time savings is a subset of transport's contribution to economic development.

In some circumstances the benefits of transport investments exceed the direct time savings to the travellers or the firms they work for. In such cases, the "willingness to pay" approach will not be an accurate estimate and will usually be an underestimate of the true benefits to society.

3.2.8 Carbon Dioxide (CO_2) emissions

The following assumptions were made for the base case analysis:

- It was assumed that 100% of the TRN traffic was redistributed on to the non-TRN roads (see Table 2). The effect on CO_2 emissions (Transport Scotland, 2015a) of the redistributed traffic was calculated for each road type.
- The ratio of emissions between non-TRN and TRN was specified as 1.3. This value was based on kilometres travelled on the TRN rural roads and the total rural kilometres, which account for 36%. Therefore, for this analysis, a 30% ratio was applied (1.3).

The values used in the base case analysis are represented by the yellow input data in the screenshots of the model in Appendix D. Further details of data sources can be found in Appendix E.

The value of CO_2 emissions was calculated in the same way as travel time and RTA savings, as the change in emissions from the current use of the TRN and the emissions if the TRN traffic moved to non-TRN roads. The savings were estimated as **0.1 tCO2e per million vehicle km**[11]. Using the DECC value (DECC, 2015) for non-traded carbon, £62 per tCO_2e, the savings were calculated at **£6 million per year**.

[10] Willingness to Pay (WTP) is the maximum price at or below which a consumer will definitely buy one unit of the product.

[11] tCO_2e is the Carbon Dioxide Equivalent (CDE) for describing how much global warming a given type and amount of GHG may cause, using the functionally equivalent amount or concentration of Carbon Dioxide (CO_2) as the reference.

Reductions in carbon emissions due to reduced fuel use also benefit air quality. This includes reductions in related pollutants such as NOx (Nitrogen Oxides), PM (Particulate Matter) and CO (Carbon Monoxide), each of which has a detrimental effect on air quality and health.

3.3 Societal impacts

User benefits

The TRN in Scotland generates a wide range of user benefits; these all need to be recognised even though reliable estimates of the impact on the economy are difficult to make due to the lack of appropriate data. These include the reduction of congestion on local non-TRN roads, which is particularly important for commuters, business and freight travel because congestion increases business costs and lowers productivity.

The removal of the TRN, or even only part of it, would lead to longer journey times and hence higher costs. This might also discourage some travellers from making certain journeys that may adversely impact on the Scottish economy. This was recognised in the literature review by Ekosgen (2016) who noted that closures on the TRN would likely impact on the "impulse" tourist market. By providing opportunities for access to a range of activities that previously would have been difficult or impossible to undertake, the TRN provides an essential service for commuters, business and leisure travellers, as well as freight operators.

Wider economic impacts

The limitations of the data for the base case analysis have not permitted the inclusion of some benefits that the TRN in Scotland nevertheless generates. The most significant are the wider economic impacts, defined as:

- Those arising where competition is not perfect;
- The additional value the government places on employment in specific areas, for example regeneration areas, over and above the same level of employment in other places.

The economic benefits to the wider economy that are missing from conventional appraisal reflect the main market imperfections:

- Agglomeration externalities
- Imperfect competition
- The economic benefits of increased employment and productivity

While it is possible for an individual transport scheme to have negative wider economic benefits (i.e. increased costs), positive wider economic benefits are generally more likely: schemes, or networks like the TRN, that facilitate faster or more reliable journeys, are beneficial. Lower transport costs lead to increased productivity and lower production costs; through better transport provision, firms are able to reap more internal economies of scale in production or obtain productivity gains from agglomeration effects.

The impact of the agglomeration externality will depend on the impact of the TRN on the "effective density" of employment in affected areas, especially urban areas. Transport improves the effective density of employment by bringing jobs closer together. However, transport can also cause employment to relocate so the overall impact of the agglomeration externality depends on the places where employment is increased, and where it is reduced, as a result of the development. There are two effects:

- One will always be positive from a transport improvement since the scheme will bring people and firms closer together (in terms of the number of minutes travelled between firms' locations, even if not the distance);
- The other impact could be either positive or negative: positive if it encourages increased employment in cities or clusters of economic activity, and negative if it encourages the dispersion of economic activity. (This effect can be positive if it reduces unemployment in, for example, a regeneration area.)

Improvements to journeys into cities would therefore be expected to have positive agglomeration benefits unless they shift activity away from a still larger city while inter-urban road improvements might have either positive or negative agglomeration effects (the first effect being positive; the latter being either positive or negative).

Agglomeration effects reflect increased productivity amongst firms and therefore contribute to GDP and hence aGVA, as highlighted by studies in the literature review (e.g. Table 1 from Arup (2014)). Wider economic benefits are not always small, so failing to consider them risks distorting decisions between transport schemes or between programmes across government, by understating the importance of the TRN.

Labour market effects

There are effects in the labour market that may generate additional impacts of transport on GDP if transport directly or indirectly causes an increase in labour supply. In this case GDP rises because time savings will impact on the labour supply decisions of some people. For some of these, the welfare impact may be smaller than the GDP effect (for example, joining the labour market means the employee needs to give up valuable spare time).

There are three separate labour market impacts on GDP from better transport such as that provided by the TRN:

- More people would be willing to enter the labour market (because access to jobs is improved)
- Employees would be willing to work longer hours (since journey times are shorter)
- Employment could be relocated from lower productivity areas to higher productivity area (i.e. agglomeration effects)

Freight benefits

The Freight sector has special needs when it comes to transport and the TRN provides particular benefits. For example, the TRN offers the possibility of fewer freight vehicles being needed in order to undertake nationwide deliveries. This might arise from the

concentration of freight depots or reduced delivery journey times. It would lead to lower vehicle operating costs for operators (e.g. lower fuel costs) that could be passed on to customers in the form of lower product costs.

Better roads (i.e. more extensive and faster) also enable the concentration of freight depots, which could lead to lower stock levels being required with consequential savings to operators and other businesses. The TRN may enable the development of Freight Distribution Centres[12] or freight exchange schemes[13] which could also lead to lower mileage for goods vehicles, the latter by reducing the level of empty "backhauling"[14]. Fewer vehicle miles driven by freight vehicles will lead to lower CO_2 emissions, better air quality and less noise. In addition there could be less congestion on the rest of the highway network.

3.4 Conclusions from the base case analysis

The quantified results of the base case analysis are shown in Table 4. The economic analysis has demonstrated that the TRN makes a significant contribution to the Scottish economy, in terms of aGVA (including per capita aGVA), tax receipts and direct employment. Of the indicators that compared the TRN to the non-TRN, or when TRN traffic was redistributed on to non-TRN roads, the road traffic accidents, time savings and CO_2 emissions showed the benefits of the TRN although modest in some cases (e.g. CO_2 emissions). Sensitivity testing has assessed the effects of different values of the parameters for aGVA and tax receipts calculations and shown the requirement for accurate data.

Table 4. Results of the base case analysis

Analysis	Value	Units
aGVA	1,380	£ million
Per Capita aGVA	44,000	£
Tax receipts	358	£ million
Employment	31,361	people
Saving in accident costs	171	£ million
Saving in travel time costs	1,644	£ million
Saving in cost of CO_2 emissions	6	£ million

[12] Freight Distribution Centres are centres, situated close to a town centre, shopping centre or construction sites, at which part loads are consolidated and from which a lower number of consolidated loads are delivered to the target area.

[13] A freight exchange system is an online service for haulage companies, logistics providers, freight forwarders and transport companies. It allows haulage companies to search a database of available freight that needs to be delivered and advertise their available vehicle capacity.

[14] "Backhauls" are return trips.

The TRN performs well by comparison with the rail network; it is a more extensive network and can be used by a variety of vehicular modes. It generates significantly more direct employment and tax receipts.

The analysis in this study is likely to underestimate the true worth of the TRN since the wider economic benefits have not been included in the calculation. Care has been taken to apply relevant data to the base case analysis and to justify all assumptions. The approach has necessitated assumptions due to the lack of economic data relating purely to the impact of the TRN, as opposed to the whole highway network, unlike for the rail sector.

The results of the base case analysis support the case for greater investment in the TRN, both in terms of ensuring that it is maintained to a high standard and extended where this is appropriate or necessary. Such investment would bring benefits in terms of economic activity, wider access to employment, fewer road traffic accidents, reduced journey times, lower CO_2 emissions, etc. It would also generate higher levels of tax receipts for investment in other areas of the Scottish economy.

3.5 Sensitivity Testing

Two separate analyses for sensitivity testing around the base case were carried out using selected parameters of the model:

- Scenario 1 – Increased spend
- Scenario 2 – Decreased spend

Chosen parameters were deemed to either increase or decrease depending on the scenario, and were changed by ± 25%. The changes as part of the sensitivity testing are summarised in Appendix F. The parameters used for each scenario were:

Scenario 1

- aGVA and Tax Receipts - Employment in Scotland increased by 25% above the base case
- RTAs – Higher traffic flows (25% above the base case), but the accident rates (per vehicle km) remain unchanged from the base case
- Travel time – Higher traffic flow (as in the RTA analysis) but no change from the base case in the average traffic speeds on each road type
- CO_2 emissions - Higher traffic flows (as in the RTA analysis), but the emission rate (per vehicle km) for each road type remains unchanged from the base case

Scenario 1 reflects increased spend in the economy, which results in increased employment and higher traffic flows. It was also assumed that with an increased spend in the economy, a higher proportion of newer vehicles with more efficient air quality and safety measures are likely to use the TRN. Hence, although there are higher traffic flows, the accident and emission rates per million vehicle kilometre remain the same.

Scenario 2

- aGVA and Tax Receipts – Employment in Scotland decreased by 25% from the base case
- RTAs – Lower traffic flows (25% below the base case), but the accident rates (per vehicle km) remain unchanged from the base case
- Travel time – Lower traffic flow (as in the RTA analysis) but no change from the base case in the average traffic speeds on each road type
- CO_2 emissions – Lower traffic flows (as in the RTA analysis), but the emission rate (per vehicle km) for each road type remains unchanged from the base case

Scenario 2 reflects decreased spend in the economy, which results in decreased employment and lower traffic flows. It was also assumed that with a decreased spend in the economy, a higher proportion of older vehicles with less efficient air quality and safety measures are likely to be on the TRN. Hence, although there are lower traffic flows, the accident and emission rates per vehicle kilometre remain the same.

Other parameters in the model were not changed. For example the percentages for the redistribution of TRN traffic to the non-TRN for the analysis of RTA, travel time and CO_2 emissions remained as shown in Table 2. Similarly the values of time, accidents and carbon are unchanged.

The results of the sensitivity testing are summarised in Table 5 and show that:

- In Scenario 1, aGVA and tax receipts generated higher annual savings from the TRN compared to the base case at **£1,725 million** due to higher employment. The annual savings were reduced for Scenario 2 at **£1,035 million** due to lower employment.
- With more traffic, the RTA savings generated by the TRN were higher for Scenario 1 at **£214 million per year** compared to the base case at **£171 million per year**. With less traffic in Scenario 2, the RTA savings were reduced to **£128 million per year**.
- The saving each year in total travel time cost increased for Scenario 1 compared to the base case to **£2,056 million** due to more traffic on the TRN. The annual savings from travel time costs reduced for Scenario 2 compared to the base case to **£1,233 million** due to less traffic on the TRN.

With higher traffic flows, the higher emissions per vehicle on the TRN resulted in CO2 emissions costing more than the base case in Scenario 1. There was an increased cost from the traffic on the TRN (rather than the same traffic using the non-TRN) of **£47 million per year**. With traffic flows lower than the base case in Scenario 2 the savings from the traffic using the TRN were more than the base case at **£59 million per year**.

Table 5. Results of the sensitivity tests

Parameter	Unit	Base Case Analysis	Scenario 1 – Increased spend	Scenario 2 – Decreased Spend
aGVA – Freight	£ million	1,021	1,277	766
aGVA – PT	£ million	207	258	155
aGVA – C&M	£ million	152	190	154
aGVA – Total	**£ million**	**1,380**	**1,725**	**1,035**
Per Capita aGVA – Freight	£	41,829	41,829	41,829
Per Capita aGVA – PT	£	41,829	41,829	41,829
Per Capita aGVA – C&M	£	75,877	75,877	75,877
Per Capita aGVA - Total	**£**	**44,000**	**44,000**	**44,000**
Tax Receipts – Freight	£ million	184	230	138
Tax Receipts – PT	£ million	29	36	22
Tax Receipts – C&M	£ million	144	180	108
Tax Receipts - Total	**£ million**	**358**	**447**	**268**
Total RTA savings from all accidents on the TRN	**£ million**	**171**	**214**	**128**
Total travel time cost	**£ million**	**1,644**	**2,056**	**1,233**
Total savings in CO_2 emissions from using the TRN over the non-TRN	**tCO_2e million**	**0.1**	**-0.77**	**0.97**
Total savings in CO_2 costs from using the TRN over the non-TRN	**£ million**	**6**	**-47**	**59**

4 Conclusions and recommendations

This study has identified the significant quantified and qualitative benefits of the TRN in Scotland. A model has been developed that can help assess the quantified benefits for the TRN and it has been used in a base case analysis and two sensitivity analyses.

4.1 Summary of key analysis results

This study has shown that:

- Economic analysis using the VaTSE model for the base case for each year:
    - TRN contributes **£1.38 billion in aGVA** (with **aGVA per capita of £44,000**)
    - TRN generates **£358 million in tax receipts**
    - TRN provides **RTA savings of £171 million from lower accident costs**
    - TRN saves **travel time costs of £1.64 billion** of using the TRN instead of using local roads
    - **CO_2 emissions** valued at **£6 million** are saved by traffic using the TRN instead of local roads
- Sensitivity testing using the VaTSE model for two scenarios found that:
    - For Scenario 1 (Increased Spend) the annual aGVA, tax receipts and RTA savings from use of the TRN all increased against the base case. The travel time costs increased but there was no benefit of the TRN from CO_2 emissions.
    - For Scenario 2 (Decreased Spend) the annual aGVA, tax receipts and RTA savings from use of the TRN all decreased against the base case. The travel time costs decreased and there was a benefit from reduced CO_2 emissions by traffic using the TRN.
- Delivering improvements and maintaining the quality of the TRN supports the following socio-economic benefits:
    - **User benefits** – Provides an essential service to commuters, businesses, leisure travellers and freight operators
    - **Wider economic impacts** – Covers agglomeration externalities, imperfect competition and economic benefits of increased employment & productivity
    - **Freight benefits** – Fewer freight vehicles are required and the TRN enables increases in freight depots and freight distribution centres
    - **Labour market effects** – More people are willing to enter the labour market (due to improved access to jobs), and to work longer hours (due to shorter journey times

4.2 Recommendations

There is a range of parameters required for the analyses carried in the VaTSE model. This study has looked at a limited range of the impacts of combinations of changes in the values of the model parameters and further examinations with more combinations of changes in the values of the key parameters will gain an improved understanding of the sensitivity of the results to the assumptions made in the model.

It is recommended that more analyses of the effects of changes in the parameter values will enhance the reliability of the estimates of the impacts of the TRN on the Scottish economy. For example, improved estimates of the traffic speeds on the different road types, the effects of traffic moving from the TRN to non-TRN roads and improved values for the accident rates on different road types would improve the reliability of the results. The sensitivity tests considered increases and decreases of 25% in the values of the same key parameters. These are wide ranges for the assessment of changes in the near future and narrower bands could show the degree of change likely over a shorter time horizon.

Improved data for the distance freight is moved on the TRN and the proportions of distance travelled on the TRN for business purposes etc. would also enable improved estimates of the benefits from the TRN.

More detailed data analysis could also better identify the direct employment numbers of those providing or using the TRN together with average salaries of construction and maintenance workers on the Scottish TRN would also improve the benefits assessment.

If precise measurements of variables where assumptions have been made could be provided then the quality of the analysis would be enhanced.

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Transport Scotland (2016g). “Scottish Transport Statistics No 34 – Datasets”, accessible at http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914

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6 Glossary

aGVA	Approximate Gross Value Added
BCR	Benefit Cost Ratio
C&M	Construction and Maintenance
CAFOD	Catholic Agency for Overseas Development
CBA	Cost Benefit Analysis
COBA	Cost Benefits Analysis
COE	Compensation of employees
CGE	Computable General Equilibrium
DfT	Department for Transport
ERF	European Union Road Federation
GDP	Gross Domestic Product
GRP	Gross Regional Product
GSP	Gross State Product
GVA	Gross Value Added
HITRANS	Highlands and Islands and Transport Partnership
HMT	Her Majesty's Treasury
MITM	Melbourne Integrated Transport Model
NPV	Net Present Value
PT	Public Transport
RTA	Road Traffic Accidents
SABS	Scottish Annual Business Survey
SIC	Standard Industrial Classification
STAG	Scottish Transport Appraisal Guidance
TBC	Transport Business Case
TEE	Transport Economic Efficiency
TRN	Trunk Road Network
WebTAG	Webbased Transport Analysis Guidance
WEI	Wider Economic Impacts

Appendix A Results of Literature Search

#	Author	Title	Year	Link
1	Transport Scotland	National Transport Strategy - January 2016	2016	http://www.transport.gov.scot/system/files/documents/reports/Main%20doc%20-%20Transport%20Scotland%20-%20National%20Transport%20Strategy%20-%20January%202016%20-%20final%20online.pdf
2	Transport Scotland	Road Asset Management Plan for Scottish Trunk Roads	2016	http://www.transport.gov.scot/sites/default/files/documents/rrd_reports/uploaded_reports/j408891/j408891.pdf
3	The Scottish Government	£254 million boost to Aberdeen	2016	http://news.scotland.gov.uk/News/-254-million-boost-to-Aberdeen-21f0.aspx
4	Terrill, M.	Roads to riches - Better transport investment	2016	http://grattan.edu.au/wp-content/uploads/2016/04/869-Roads-to-Riches.pdf
5	Litman, T.	Generated traffic and induced travel	2016	http://www.vtpi.org/gentraf.pdf
6	Venables, A. J.	Incorporating wider economic impacts within cost-benefit appraisal	2016	http://www.itf-oecd.org/sites/default/files/docs/incorporating-wider-economic-impacts-cba.pdf
7	Frontier Economics Ltd	Assessing the productivity benefits of improving inter-city connectivity in Northern England	2016	Provided by Transport Scotland
8	Marsden, G., Anable, J., Shires, J. and Docherty, I.	Travel behaviour response to major transport system disruptions - Implications for smarter resilience planning	2016	Provided by Transport Scotland
9	Audit Scotland	Maintaining Scotland's roads	2016	Provided by Transport Scotland
10	World Road Association	Preserve your country's roads to drive development	2016	Suggested by Transport Scotland - http://www.piarc.org/en/order-library/24521-en-Preserve%20your%20Country-s%20roads%20to%20Drive%20Development.htm
11	Amey for Kent County Council	Transport Business Case Report - Maidstone Integrated Transport Package (MITP)	2016	http://www.southeastlep.com/images/uploads/resources/LGFSE43_Maidstone_ITP_Business_Case.pdf
12	Parsons Brinckerhoff	M25 J25 WebTAG environmental appraisal summary report	2016	www.somerset.gov.uk/EasySiteWeb/GatewayLink.aspx?alId=113688
13	Ekosgen	Argyll and Bute Transport Connectivity and Economy Research Report - June 2016	2016	http://www.hie.co.uk/regional-information/economic-reports-and-research/archive/argyll-and-bute-transport-connectivity-and-economy-research.html
14	The Scottish Government	Scotland's Economic Strategy	2015	http://www.gov.scot/Resource/0047/00472389.pdf
15	Butcher, L.	Strategic road network - Briefing Paper from House of Commons	2015	www.parliament.uk/briefing-papers/SN01448.pdf

#	Author	Title	Year	Link
		Library		
16	North Ayrshire Council	North Ayrshire Local Transport Strategy	2015	http://www.north-ayrshire.gov.uk/Documents/PropertyServices/InfrastructureDesign/Roads/local-transport-strategy-draft.pdf
17	National Assembly for Wales Public Accounts Committee	Value for money of motorway and trunk road investment	2015	http://www.assembly.wales/laid%20documents/cr-ld10271/cr-ld10271-e.pdf
18	Wang, B.	Estimating economic impacts of transport investments using TREDIS: a case study on a National Highway Upgrade Program	2015	www.bts.nsw.gov.au/ArticleDocuments/82/Estimating%20economic%20impacts%20of%20transport%20investments%20using%20TREDIS.pdf.aspx secondary impacts of highway investments
19	Office for National Statistics	Quality and methodology information - Regional Gross Value Added (Income Approach)	2015	Provided by Transport Scotland
20	Canning, S., Thomas, R. and Wright, S.	Research into the social and economic benefits of community transport in Scotland	2015	Provided by Transport Scotland
21	Jacobs - Lancashire County Council	A682 Centenary Way Viaduct refurbishment scheme - Benefit cost analysis and gross value added assessment technical note	2015	http://www.lancashirelep.co.uk/media/12496/Appendix-D-Benefit-Cost-Analysis-and-Gross-Value-Added.pdf
22	Byett et al.	Assessing new approaches to estimating the economic impact of transport interventions using the gross value added approach - March 2015	2015	https://www.nzta.govt.nz/assets/resources/research/reports/566/docs/566.pdf
23	Campaign for Better Transport	Better not bigger - Why strategic roads need a green retrofit programme	2014	http://www.bettertransport.org.uk/sites/default/files/Roads_Retrofit_Proposals_FINAL_Sep2014.pdf
24	Metsäranta, H. et al.	The wider economic impacts of transport investments	2014	http://www.helsinki.fi/ruralia/asiantuntijapalvelut/ytp_fin/pdf/BGLC_WP_53_report_Final_12022014.pdf
25	Ministry of Transport	Contribution of transport to economic development: International literature review with New Zealand perspectives	2014	Provided by Transport Scotland
26	Venables, A. J., Laird, J.	Transport investment and economic	2014	Provided by Transport Scotland

#	Author	Title	Year	Link
	and Overman, H.	performance: Implications for project appraisal		
27	Welsh Government	M4 Corridor around Newport - Motorway to the South of Newport - Business Case 2014	2014	http://www.m4newport.com/assets/business-case-20142.pdf
28	DfT	Transport analysis guidance: WebTAG	2014	https://www.gov.uk/guidance/transport-analysis-guidance-webtag
29	DfT	Transport analysis guidance - The transport appraisal process	2014	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/431185/webtag-tag-transport-appraisal-process.pdf
30	DfT	The strategic road network and the delivery of sustainable development	2013	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/237412/dft-circular-strategic-road.pdf
31	Visit Scotland	Tourism development framework in Scotland - role of the planning system in delivering the visitor economy	2013	http://www.visitscotland.org/pdf/Tourism%20Development%20Framework%20-%20FINAL.pdf
32	Sanchis-Guarner, R.	Does road building produce any economic gains? Not many, the evidence suggests	2013	http://blogs.lse.ac.uk/politicsandpolicy/does-road-building-produce-any-economics-gains/
33	Glaister, S.	The economics of road maintenance - An RAC foundation view	2013	http://www.racfoundation.org/assets/rac_foundation/content/downloadables/economics_of_road_maintenance-an_racf_view-june_2013.pdf
34	DfT	The Transport Business Cases	2013	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/85930/dft-transport-business-case.pdf
35	Parkman, C.C., Bradbury, T, Peeling, D and Booth, C.	Economic, Environmental and Social Impacts of Changes in Maintenance Spend on Local Roads in Scotland	2012	TRL study
36	Campaign for Better Transport	Going backwards - The new roads programme	2012	http://www.bettertransport.org.uk/sites/default/files/research-files/Roads_to_Nowhere_October2012_web_spreads_0.pdf
37	Næss, P., Nicolaisen, M. S. and Strand, A.	Traffic Forecasts Ignoring Induced Demand: a Shaky Fundament for Cost-Benefit Analyses	2012	http://www.ejtir.tbm.tudelft.nl/issues/2012_03/pdf/2012_03_02.pdf
38	Mott Macdonald	A47 Wider Economic Benefits	2012	http://www.a47alliance.co.uk/assets/AgendasMinutes/Wider-Economic-Benefits-A47.pdf
39	Parsons Brinckerhoff	A303, A358 and A30: Corridor Improvement Programme Economic Impact Study - Final Draft	2012	http://www.southsomerset.gov.uk/media/455618/background_papers_to_motion_economicimpactstudy_draftv1_9i1__1_.pdf

#	Author	Title	Year	Link
40	Cook, A.	A fresh start for the strategic road network - Managing our roads better to drive economic growth, boost innovation and give road users more for their money	2011	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/4378/strategic-road-network.pdf
41	Smith, J. W., Jan, A. and Phillips, D.	Providing and funding strategic roads - An international perspective with lessons for the UK	2011	www.arup.com/~/media/Files/PDF/Publications/Research_and_whitepapers/REPORT_Providing_and_Funding_Strategic_Roads_Arup_and_RAC.ashx value of trunk road network economy
42	Kernohan, D. and Rognlien, L.	Wider economic impacts of transport investment in New Zealand September 2011	2011	http://www.nzta.govt.nz/assets/resources/research/reports/448/docs/448.pdf
43	Ernst & Young	Economic contribution of the development of the Victorian road network since 1996	2010	http://s3.amazonaws.com/zanran_storage/www.transport.vic.gov.au/ContentPages/762826031.pdf
44	American Association of State Highway and Transportation Officials	User and non-user benefit analysis for highways	2010	https://bookstore.transportation.org/imageview.aspx?id=884&DB=3
45	Office for National Statistics	Measuring the economic impact of an intervention or investment	2010	www.ons.gov.uk/ons/rel/regional-analysis/measuring-the-economic-impact-of-an-intervention-or-investment/measuring-the-economic-impact-of-an-intervention-or-investment/economic-impact--paper-one.pdf
46	Ernst & Young	The economic contribution of Sydney's toll roads to NSW and Australia	2008	http://infrastructureaustralia.gov.au/policy-publications/publications/files/Eco_contribn_of_sydney's_Toll-Roads_EY2008.pdf
47	McDowall, E. and Adams, C.	Locally significant roads: An investment strategy (HITRANS)	2008	https://www.hitrans.org.uk/Documents/Locally_Significant_Roads_Study_Report.pdf
48	Transport Scotland	Scottish Transport Appraisal Guideline	2008	http://www.transport.gov.scot/sites/default/files/documents/rrd_reports/uploaded_reports/j9760/j9760.pdf
49	Welsh Assembly Government	Welsh Transport Planning and Appraisal Guideline	2008	http://www.wales.nhs.uk/sites3/Documents/522/final%20weltag%20guidance.pdf
50	Bose, R., Kohli, S., van Vuren, T. and Mott Macdonald	Using the impacts of active traffic management rollout project to discuss wider economic benefits in transport appraisal	2008	http://abstracts.aetransport.org/paper/index/id/2912/confid/14
51	Ipsos Mori and Steer Davies	Transport Infrastructure and Services: Industry Views	2008	http://www.scottish-enterprise.com/~/media/se/resources/documents/stuv/transport-infrastructure-and-services.

#	Author	Title	Year	Link
	Gleave			
52	Various	Regional Transport Strategy serving Dumfries and Galloway	2008	http://www.swestrans.org.uk/index.aspx?articleid=9691
53	Eddington, R.	The Eddington Transport Study - Main Report: Transport's role in sustaining the UK's productivity and competitiveness	2006	http://webarchive.nationalarchives.gov.uk/20090104005813/http:/www.dft.gov.uk/162259/187604/206711/volume1.pdf
54	Johansson, S.	Socio-economic impacts of road conditions on low volume roads - Results of literature studies, interviews and calculations with a model and some proposals for road management policies	2006	http://www.roadex.org/wp-content/uploads/2014/01/Socio-economic_English.pdf
55	Halcrow	Investment in lifeline rural roads – Problems, issues and constraints report	2003	Not found - summary provided in Johansson (2006)
56	Social Exclusion Unit	Making the connections: Final report on transport and social exclusion	2003	http://www.ilo.org/wcmsp5/groups/public/@ed_emp/@emp_policy/@invest/documents/publication/wcms_asist_8210.pdf
57	Chalermpong, S.	Economic spillovers of highway investment: A case study of the employment impacts of Interstate 105 in Los Angeles County	2002	http://www.uctc.net/research/diss141.pdf
58	Carey, J.	Impact of highways on property values: Case study of the Superstition Freeway Corridor	2001	http://ntl.bts.gov/lib/24000/24800/24842/AZ516.pdf
59	Economic Development Research Group Inc. and Cambridge Systematics Inc.	Using empirical information to measure the economic information to measure the economic impact of highway investments - Volume 1: Review of literature, data sources and agency needs	2001	http://www.edrgroup.com/pdf/fhwa-hwy-impact-vol-1.pdf
60	Economic Development Research Group Inc. and Cambridge Systematics Inc.	Using empirical information to measure the economic information to measure the economic impact of highway investments - Volume 2: Guidelines for data collection and	2001	http://www.edrgroup.com/pdf/fhwa-hwy-impact-vol-2.pdf

#	Author	Title	Year	Link
		analysis		
61	ERF	ERF's position on the socio-economic benefits of road to society	2001	Provided by Transport Scotland
62	DfT	Transport and the economy: full report (SACTRA)	1997	http://webarchive.nationalarchives.gov.uk/20050301192906/http:/dft.gov.uk/stellent/groups/dft_econappr/documents/pdf/dft_econappr_pdf_022512.pdf
63	Wood D. A.	Trunk roads and the generation of traffic	1994	http://www.bettertransport.org.uk/sites/default/files/trunk-roads-traffic-report.pdf
64	Transportation Economics Committee of TRB	Economic effects	XXXX	http://bca.transportationeconomics.org/benefits/economic-effects
65	CAG Consultants for Friends of the Earth	New jobs without new roads - Sustainable regeneration in Hastings	XXXX	https://www.foe.co.uk/sites/default/files/downloads/new_jobs_without_roads.pdf
66	Campaign for Better Transport	New roads create new traffic	XXXX	http://www.bettertransport.org.uk/roads-nowhere/induced-traffic
67	World Bank	Induced traffic and induced demand	XXXX	http://www.worldbank.org/transport/roads/rpl_docs/apbinduc.pdf

Note: References shown in green were assessed as particularly relevant to the TRN in Scotland. Full details can be found in Appendix B.

Appendix B Summary of relevant documents from the literature review[15]

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
1	Transport Scotland (2016) "National Transport Strategy "	-	Scotland	Transport including TRN	Five high level objectives focused on economic growth, social inclusion, environment/health, safety and integration.	-
5	Litman (2016) "Generated traffic and induced travel"	Literature based review - methodologies discussed include FHWA Spreadsheet Model for Induced Travel Estimation and integrated transport/land use models (e.g. TRANUS and MEPLAN)	Global	-	Traffic congestion reaches a point at which it constrains further growth. If the road capacity increases, the number of peak-period trips also increases until congestion again limits further traffic growth. The additional travel is called "generated traffic." Project appraisal considers: 1) Generated traffic reduces the predicted congestion reduction benefits of road capacity expansion 2) Induced travel imposes costs, including downstream congestion, accidents, parking costs, pollution, and other environmental impacts 3) The additional travel that is generated provides relatively modest user benefits, since it consists of marginal value trips	-

[15] As shown in Appendix A

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
10	World Road Association (2016) "Preserve your country's roads to preserve development"	-	Global	Main focus on TRN	Focus on importance of maintenance of roads but addresses how road transport is at the heart of the economy and drives sectors such as services and tourism.	-
13	Ekosgen (2016) "Argyll and Bute Transport Connectivity and Economy Research Report"	Study was in line with STAG principles.	Argyll and Bute region	Transport within Argyll and Bute region	Focus on importance of links of transport to different sectors such as food and drink, and tourism.	-
14	The Scottish Government (2015) "Scotland's Economic Strategy"	-	Scotland	-	Scotland's economic framework is focused on four key priorities for sustainable growth: Investment, innovation, inclusive growth and internationalism.	
16	North Ayrshire Local Transport Strategy (2015)	-	Local communities in North Ayrshire	All roads in North Ayrshire including trunk roads	Local Transport Strategy Objectives include Economy, Accessibility and Social Inclusion, Safety, Environment and Integration. The growing number of elderly people was recognised and the need for increases in CT	North Ayrshire's road network is estimated at a value of approximately of £1.7 billion (anecdotal, not clear where this value came from)
18	Wang (2015) "Estimating economic impacts of transport investments using TREDIS: a case study on a National Highway Upgrade	The Transport Economic Development Impact System (TREDIS) is an econometric impact analysis system that includes cost and	Australia	National highway upgrade program	Economic impact outputs from TREDIS include business output, value added, employment, wage income effect and economic impacts by industry sector.	Provides useful insights on likely economic impacts of road upgrades. The economic impacts are significant with each $1 million investment generating more than $2

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
	Program"	price-response elements and dynamic changes similar to CGE models. Other quantification methods discussed in this report.				million business output and $0.9 million GDP.
20	Canning et al. (2015) "Research into the social and economic benefits of community transport in Scotland"	Anecdotal - questionnaire-based survey of community transport (CT) users and in-depth interviews with CT providers	One CT case study from each of: 1) large urban area, 2) other urban area, 3) remote small town and 4) accessible rural and 5) remote rural	-	CT addresses issues such as accessibility poverty, improved access to health services, tackling isolation and promoting social inclusion	5 case studies for CT were estimated to generate £2.8m per annum in Gross Value Added (from interviews). CT offers significant cost savings to local authorities, NHS and public bodies and a range of benefits across policy areas.
24	Metsäranta et al. (2014) The wider economic impacts of transport investments	Interviews and surveys, market studies, comparative analysis through case studies, land-use transport interaction simulation models,	-	-	Wider economic impacts such as agglomeration impacts, imperfect market impacts, labour supply and job relocation impacts, and land-use and property values	-

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
		economic multiplier input-output models, computable general equilibrium models and integrated computable general equilibrium-transport models				
26	Venables et al. (2014) "Transport investment and economic performance: Implications for project appraisal"	1) User benefits - Forecasting of traffic flow and travel demand 2) Productivity effects - A measure of access to economic mass for each place 3) Employment effects - calculating benefits of land-use change	-	-	Appraisal guide looked at three different impacts: 1) User benefits (comprise of savings in time and vehicle operating costs) 2) productivity effects (improved economic interactions between firms & improved concentrations of workers in cities) 3) employment effects (attracting private sector investment consequent employment)	From Gibbons and Machin (2003) – On Jubilee lines & DLR extensions, proximity to stations raises property prices by 9.3%, consistent with estimates of the value of time savings from being close to a station.
31	Visit Scotland (2013) Tourism development framework in Scotland - role of the planning	-	Scotland with a focus on particular schemes	Schemes included on the trunk road	Upgrades to routes with tourism potential need to consider a wide range of factors to maximise benefit to the visitor economy including ease of connectivity to tourist destinations; opportunities to incorporate vistas	-

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
	system in delivering the visitor economy			network	in route design and stopping places along the route to take advantage of scenic views. There is a further opportunity to take matters into account through design statements for route infrastructure improvements.	
35	Parkman et al. (2012) "Economic, Environmental and Social Impacts of Changes in Maintenance Spend on Local Roads in Scotland"	Qualitative and quantitative assessments both carried out to assess economic, environmental and social impacts of cuts to road maintenance budgets	Scotland	Local roads	Literature review looked at different user groups and impacts such as noise and vibration, air quality, cultural and landscape, security, community and accessibility.	-
36	Campaign for Better Transport (2012) "Going backwards – The new roads programme"	An assessment of local plans and HE trunk road projects to identify which projects were most likely to be revived and promoted first. Detailed route maps and length data were available.	UK	Local roads and trunk roads	Negative impacts of road building include: 1) Increased traffic pressure on surrounding local network 2) Negative impact on conservation, landscape and heritage reasons 3) Extensive impact on agricultural land and the green belt with intention of schemes to open up land for development 4) Increased problems for job seekers with no access to	Furthermore, in 2011, Campaign for Better Transport collected figures on 19 completed bypasses and found an average increase in cost from initial business plan to completion of 75%.

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
					car with reduced focus on improving public transport	
37	Næss et al. (2012) "Traffic Forecasts Ignoring Induced Demand: a Shaky Fundament for Cost-Benefit Analyses"	2 appraisals were chosen for a selected Danish road project in a congested transport corridor; one which included induced traffic (model A), and one which did not (model B). The results were then compared to see whether inclusion of induced traffic in the transport model resulted in a reduction of estimated benefits in a CBA.	Denmark	Local scheme	Even though the model calculations included only a part of the induced traffic, the difference in cost-benefit results compared to the model excluding all induced traffic was substantial. The results showed lower travel time savings, more adverse environmental impacts and a considerably lower benefit-cost ratio.	-
38	Mott Macdonald (2012) "A47 Wider Economic Benefits"	CBA and GVA - benefits were split up between transport and socio-economic benefits. Software used included TrafficMaster	Norfolk	Trunk road	Economic impacts modelled include creation of jobs, investment, GVA and housing. A qualitative assessment on settlement growth.	Focusing on development sites identified, it is anticipated that if road improvements take place within 20 years, there will be an increase of 9,615 jobs and £390 million per

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
		data to calculate average speed of sections, predicted traffic growth using the National Transport Model and DfT Tempro database and understanding benefits of dualling sections using COBA speed-flow curves				annum in GVA, which equates to £3 billion NPV.
39	Parsons Brinckerhoff (2012) "A303, A358 and A30: Corridor Improvement Programme Economic Impact Study - Final Draft"	Transport Economy Efficiency approach used WebTAG and COBA software. Wider Economic Impacts assessment used GVA and enhanced by business/tourism surveys. Impacts were modelled with the gathering of assumptions,	South West	Trunk road	Different types of impacts analysed included: 1) Economic output-related (e.g. GVA by region) 2) Employment related (e.g. 'headline' employment such as welfare savings) 3) Tourism-related (e.g. increase in visitor numbers 4) Land use and development-related (e.g. land value increases) 5) Other impacts (e.g. increased disposable income)	Predicted increase in GVA, based on 2022 opening of £74.5bn over 60 years. Scheme to generate approximately 20,700 jobs in the area. The tourism benefits calculated range from £13.1bn (2017 opening) to £10.8bn (2027 opening).

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
		'baseline' economic data such as up-to-date GVA data, employment data, tourism data and other stats covering taxation etc				
42	Kernohan and Rognlien (2011) Wider economic impacts of transport investment in New Zealand September 2011"	Development of the following methodology: 1) Inputs of transport model, economic and employment data, land-use models & wider economic impact parameters 2) Intermediate variables of average generalised cost & effective density. Calculations were then described for each of the five wider	New Zealand	Additional Waitemata Harbour Crossing	The theory of the wider economic impacts of transport supposes schemes can produce benefits through five main effects that are additional to the standard cost-benefit analysis approach to appraisal: 1) Agglomeration benefits 2) Imperfect competition benefits 3) Increased competition benefits 4) Labour supply benefits 5) Job relocation benefits	The wider economic impacts of the AWHC project are likely to be worth around $106.6m in NPV (2010 prices). Agglomeration impacts account for the largest component wider impacts for the project with a total $72m impact in net present value.

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
		economic impacts.				
43	Ernst and Young (2010) Economic contribution of the development of the Victorian road network since 1996	A 3-step approach was used to calculate the net benefits & wider economic benefits of the development of the Victorian roads: 1) Estimating the standard economic costs and benefits 2) Extending the standard CBA to include the "Wider Economic Benefits" 3) Computable general equilibrium economic contribution analysis	Australia	Victoria area	The following wider economic benefits were estimated: Agglomeration, Increased competition, Imperfect competition, Labour supply and Economies of scale.	Using a standard cost-benefit framework, the net benefit of the construction/operation of the network has been calculated to be $159.2 billion, over the evaluation period. The wider economic benefits were estimated to be $15.6 billion in 2008 dollars.
46	Ernst and Young (2008) "The economic contribution of Sydney's toll roads to NSW and Australia"	Review of benefit-cost analysis for toll roads and use of up-to-date publicly available data. Computable General Equilibrium (CGE)	Australia	Impact of toll road on both NSW and Australia's economy	Direct benefits of Sydney's toll road network include travel time savings, vehicle operating cost savings, and reduced accidents and vehicle emissions. Network benefits include an expansion in the geographic coverage of the network & improved accessibility. This includes improved operability within the network with	The review of the total economic contribution of Sydney's toll road network indicated a NPV of $22.7 billion, approximately 15% greater than the sum of the

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
		modelling was used ('The Enormous Regional Model' (TERM)). Industry and socioeconomic data (anecdotal/qualitative) was analysed to demonstrate the impact of the toll roads on households and businesses.			greater connectivity. Major enabler of significant socio-economic change including population expansion by facilitating improved access to areas of employment, industrial and commercial change, and facilitation of new residential development areas and impacts on property prices for existing residential areas.	initial valuations undertakes. Increasing Gross State Product over time, ranging from $1.6 million in 1986 to $3.4 billion in 2020 by increasing real private consumption, real investment and overseas trade.
47	McDowall and Adams (2008) Locally significant roads: An investment strategy (HITRANS)	Assessed current conditions and constraints on locally significant road network and considered social and economic impacts of investment on the network.	Scotland	Local roads	Discussion of social and economic benefits for different schemes such as improved accessibility for remote communities, encouraging expansion of industry in areas and promotion of tourism	-
49	Welsh Transport Planning and Appraisal Guidance (2008)	Description of methodology used to appraise transport projects in Wales to ensure that they	Wales	-	Addresses economic impacts such as transport economic efficiency (TEE) and social impacts such as transport safety, personal security and social inclusion.	-

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
		consider the economy, environment and society.				
50	Bose et al. (2008) "Using the impacts of active traffic management rollout project to discuss wider economic benefits in transport appraisal"	Used the DfT (2005) methodology for the appraisal of transport schemes of wider economic benefits. PRISM (Policy Responsive Integrated Strategy Model) was used, which is a state of the art disaggregate demand model with significant detail in zoning and networks. Calculations in the DfT guidance were carried out for GDP per worker, net agglomeration benefit, labour changes from transport interventions	West Midlands	Trunk road	Calculations of wider economic benefits include impacts of welfare (agglomeration benefits, increased output in imperfectly-competitive markets and improved labour supply), GDP (more people working, people working longer hours in the same job and people working in more productive jobs)	The biggest component of the wider economic benefits due to ATMwas the agglomeration benefits (about 9%). The key driver was the change in employment density of the zones in the model area.

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
54	Johansson (2006) "Socio-economic impacts of road conditions on low volume roads - Results of literature studies, interviews and calculations with a model and some proposals for road management policies"	Literature review	Europe	Rural roads in Europe	Discusses "lifeline" concept of roads and social importance.	
55	Halcrow (2003) Investment in lifeline rural roads – Problems, issues and constraints report	This reference could not be located so a summary from Johansson (2006) was used. STAG and TEE were used.	Rural communities in Scotland	"Lifeline" roads in Scotland	Looked at the causal link between condition of "lifeline" road and social/economic vitality of rural community.	
56	Social Exclusion Unit (2003) "Making the connections: Final report on transport and social exclusion"	-	UK	-	Examined the links between social exclusion, transport and the location of services.	-
61	ERF (2001) "ERF's position on the socio-economic benefits of	Literature based review	Global	-	Mainly positive impacts of road transport discussed: 1) contribution to public finances 2) direct/indirect effects on employment & creation of dynamic feedback loops 3)	-

No.	Reference	Methodology of quantification	Focus of communities	Trunk road focus?	Societal/Economic impacts?	Quantification in statements?
	road to society"				Increases in labour supply 4) upward social mobility and integration and 5) Improved accessibility to job opportunities	
65	CAG Consultants (n.d.) "New jobs without new roads - Sustainable regeneration in Hastings"	Literature based review	Hastings	Trunk road	While the scheme would open up development land in North Bexhill for the construction of 1,500 homes and 40 hectares of employment land, it was argued that sustainable regeneration of Hastings through other methods would have a much more positive impact.	-

Appendix C Quantitative assessment methods/frameworks

STAG

STAG (Transport Scotland, 2016e) provides a clear and robust framework to identify and appraise the impacts of potential transport interventions and investments. It is objective-led rather than solution-led in order to avoid pre-conceived solutions being brought forward without considering other options which may better meet the identified problem or opportunity.

STAG can be used in all transport appraisal contexts, including transport and development policies or strategies. It is a single process incorporating Pre-Appraisal, Appraisal and Post Appraisal. Pre-Appraisal provides the foundation to the process since it promotes the analysis of opportunities in parallel with the identification of transport problems. It does not prioritise between options; rather it is an aid to decision makers to allow them to make informed choices. STAG may provide an initial rationale for investment and it is important that the STAG outcomes are revisited as the Business Case for an intervention develops. A STAG appraisal is complementary to a Transport Assessment[16].

A STAG appraisal requires more detailed checks to identify complementary or conflicting impacts with the wider Scottish policy context. Additional benefits on disability, health and rural matters together with further social inclusion impacts should also be outlined. This provides a check for compliance with legislation and policy in addition to specific accessibility issues including:

- Disability
- Health
- Rural affairs
- Social Inclusion

As with most appraisal methods, STAG is targeted at assisting the selection of the most appropriate intervention to satisfy transport, rather than economic objectives. As an appraisal method it is applied to the assessment of individual project proposals rather than the benefits of an existing network and so has therefore been discounted as not being suitable for this study.

WebTAG (Web-based Transport Analysis Guidance)

WebTAG (Department for Transport, 2016a) is the Department for Transport (DfT) transport appraisal guidance and toolkit. It consists of software tools and guidance on transport modelling and appraisal methods that are applicable for transport interventions. These facilitate the appraisal and development of proposals, helping to build evidence to support business case developments and to inform investment funding decisions. Development of

[16] A Transport Assessment sets out the transport issues relating to a proposed development, identifying what measures will be taken, the anticipated impacts and safety for all modes of travel.

an analysis using WebTAG guidance is a requirement for all interventions that require DfT approval.

WebTAG is based on Her Majesty's Treasury (HMT) Green Book (HM Treasury 2011) that sets out the framework for appraisal and evaluation for all policies, programmes and projects. Monetary valuations are applied to the respective impacts to enable Cost-Benefit Analysis (CBA) comparisons to be made. Some of the valuations can be taken directly from market prices or predictions of prices in future markets (e.g. fuel prices or values of carbon emissions).

Other valuations have been derived from research using techniques such as hedonic pricing and stated preference (e.g. the valuation of some noise impacts and the value of travel time savings). Where valuations rely on research or experimental methods, they are reviewed by experts to ensure that they are sufficiently robust to be used in a CBA. To ensure that decision-makers are always presented with a full account of the impacts, all the impacts (monetised, quantified and qualitative wherever feasible) are summarised and presented in the form of an Appraisal Summary Table (AST). WebTAG gives advice on the appraisal of the social impacts and distributional impacts of transport interventions. Reliability impacts on commuters and other users, access to services, severance, and affordability are also addressed. WebTAG therefore covers a wide range of impacts, not only the economic impacts.

These approaches are not necessarily mutually exclusive: for example a TBC analysis would typically be undertaken as part of a STAG or WebTAG appraisal of a transport proposal.

TBC (Transport Business Case)

The TBC approach shows whether proposed schemes are:

- Supported by a robust case for change that fit with wider public policy objectives – the 'strategic case'
- Demonstrate value for money – the 'economic case'
- Are commercially viable – the 'commercial case'
- Are financially affordable – the 'financial case'
- Are achievable – the 'management case'

The Outline Business Case is used to align the progress of the project towards achieving the overall objectives. It confirms the strategic fit and the case for change and sets out a detailed assessment of the options to find the preferred solution. It also refines the investment/intervention proposal and provides details of the project's overall balance of benefits and costs against objectives.

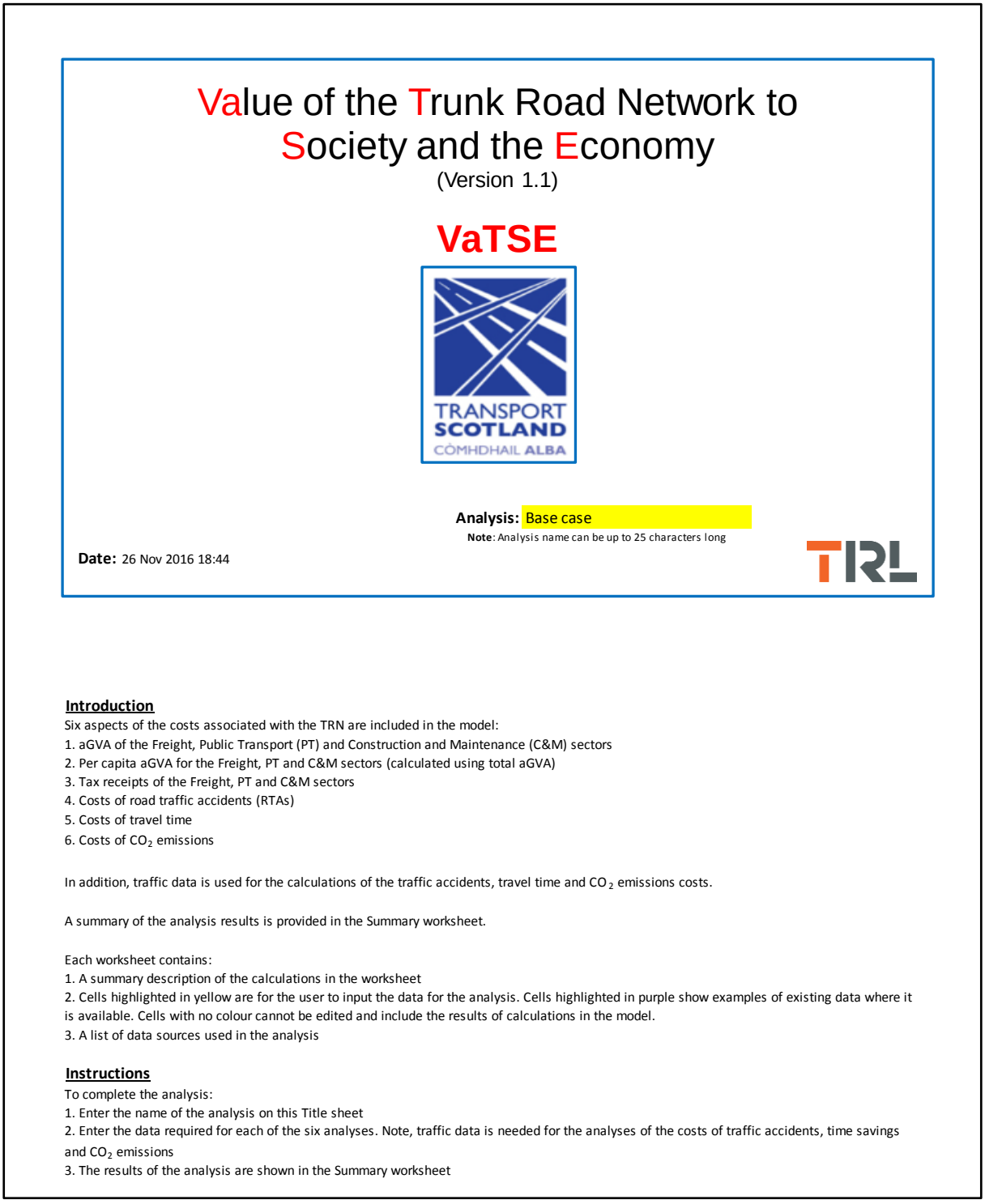
The Full Business Case should also set out plans for monitoring and evaluating these benefits when required. It will confirm that the strategic fit and the case for change provide the business and financial rationale for the project as well as details of the proposed contract management, resourcing, processes and benefit realisation plans. The Full Business Case will show how the return would justify the overall investment of time and money and

should continue to be used to align the progress of the project towards achieving its business objectives. The economic case assesses options to identify all of the impacts, and the resulting value for money. Impacts considered are not limited to those directly affecting the measured economy, nor to those that can be monetised. The economic, environmental, social and distributional impacts of a proposal are all examined, using qualitative, quantitative and monetised information. In assessing value for money, all of these are consolidated to determine the extent to which the benefits outweigh the costs.

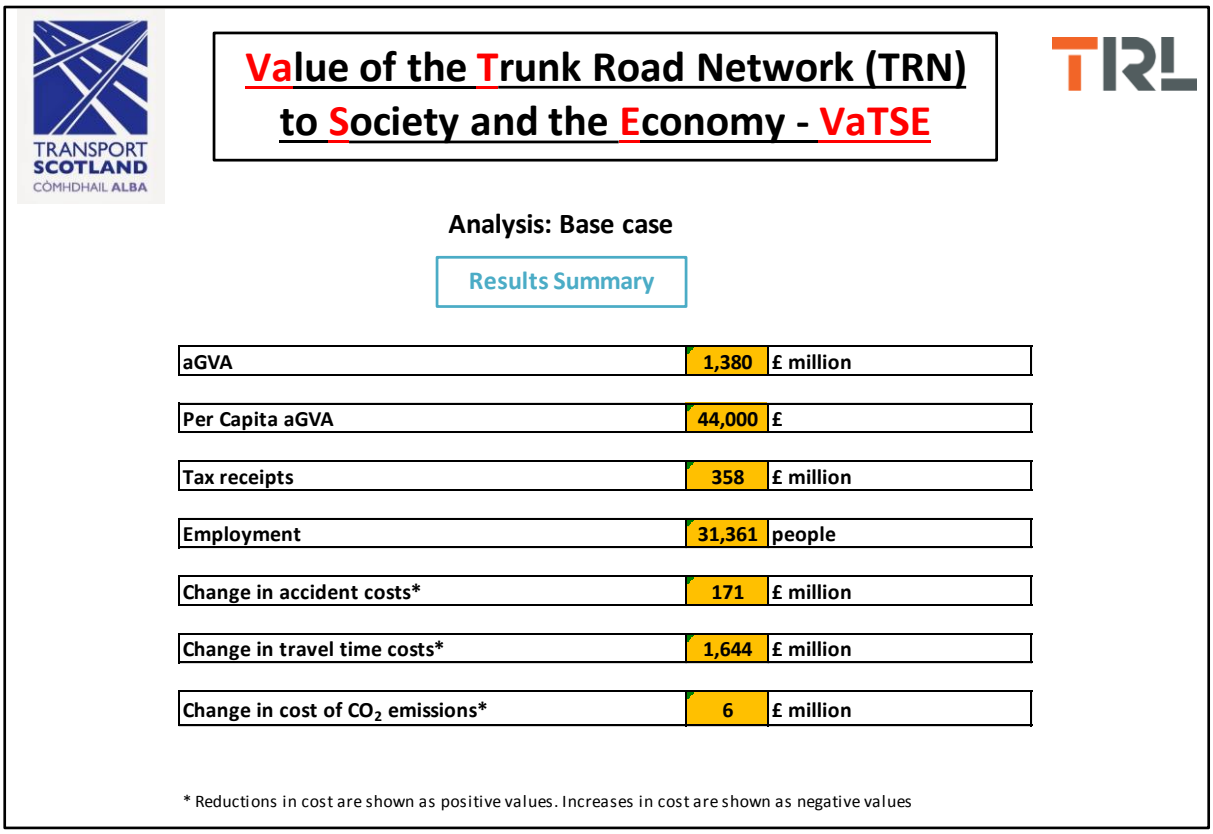
The business case in Transport Scotland's procedures is integrated within the STAG process and so should be considered as part of that process, rather than as an alternative. As for STAG, the TBC approach is directed more towards estimating the costs and benefits of a specific intervention rather than the impacts of the TRN in Scotland. A methodology, or approach, to undertake an appraisal of an existing network requires different capabilities to those that are only considering one or a few potential options for a scheme.

Appendix D VaTSE - Screenshots of the model

Title screen



Summary screen



Value of the Trunk Road Network (TRN) to Society and the Economy - VaTSE

Analysis: Base case

Results Summary

aGVA	1,380	£ million
Per Capita aGVA	44,000	£
Tax receipts	358	£ million
Employment	31,361	people
Change in accident costs*	171	£ million
Change in travel time costs*	1,644	£ million
Change in cost of CO_2 emissions*	6	£ million

* Reductions in cost are shown as positive values. Increases in cost are shown as negative values

aGVA screen

Value of the Trunk Road Network (TRN) to Society and the Economy - VaTSE

Analysis: Base case

Approximate Gross Value Added (aGVA)

This sheet contains the calculations for aGVA. Existing data from 2010 to 2014 is provided where it is available (see the table below for the data sources).

aGVA is calculated for each sector by:

aGVA = (GVA per head * Total employment on the TRN)

Key

User to enter value

Existing data

Freight

Parameter	Unit	Analysis	Existing Data				
			2014	2013	2012	2011	2010
GVA per head for Land Transport and Transport via Pipelines	£	41,829	41,829	41,686	38,670	38,395	34,273
Total employment in Freight (Road) in Scotland	No.	37,000		37,000			
% of Freight employment on TRN	%	66					
Total employment of Freight in Scotland on TRN	No.	24,420					

Public Transport (PT)

Parameter	Unit	Analysis	Existing Data				
			2014	2013	2012	2011	2010
GVA per head for Land Transport and Transport via Pipelines	£	41,829					
Total employment in PT (Road) in Scotland	No.	18,300					18,300
% of PT employment on TRN	%	27					
Total employment of PT in Scotland on TRN	No.	4,941					

Construction & Maintenance (C&M)

Parameter	Unit	Analysis	Existing Data				
			2014	2013	2012	2011	2010
GVA per head for Civil Engineering	£	75,877	75,877	79,109	55,775	71,590	65,769
Total employment in Civil Engineering (Road) in Scotland	No.	15,100	15,100	16,100	17,100	16,400	20,200
% of C&M employment on TRN	%	13					
Total employment of C&M in Scotland on TRN	No.	2,000					

Total aGVA Summary Table

Parameter	Unit	Analysis
Freight	£ million	1,021
Public Transport (PT)	£ million	207
Construction & Maintenance (C&M)	£ million	152
Total	**£ million**	**1,380**

aGVA Data Sources

Parameter	Data Source
GVA per head for Freight and PT	SABS data - GVA per head for SIC code 49 (Land Transport and Transport via Pipelines) *http://www.gov.scot/Topics/Statistics/Browse/Business/SABS/ScotDiv*
GVA per head for C&M	SABS data - GVA per head for SIC code 42 (Civil Engineering) *http://www.gov.scot/Topics/Statistics/Browse/Business/SABS/ScotDiv*
Total employment numbers for Freight	Employment total of 37,000 for road freight analysis from 2013, which was supplied by Transport Scotland
Total employment numbers for PT	Employment total of 18,300 for 2010/11 which was supplied by Transport Scotland. This figure was used because the DfT publication of staff employed by local bus operators for Scotland has not changed between 2010/11 and 2015/16.
Total employment numbers for C&M	SABS data - Employment total for SIC code 42 (Civil engineering) *http://www.gov.scot/Topics/Statistics/Browse/Business/SABS/ScotDiv*
% of Freight employment for the TRN	Set at 66% to reflect the % of total HGV vehicle kilometres on TRN in 2014 *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*
% of PT employment for bus and coach drivers for the TRN	Set at 27% to reflect the total bus traffic on the TRN in 2014 *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*
% of civil engineering employment for the TRN	Set at 13.245% to produce an employment total of 2,000 for the TRN. The value of 2,000 is made up of two figures - 1,300 (from BEAR at link below) and 700 (Weighted value of UK wide employment for construction of roads and motorways (SIC code 42.11) for Scotland TRN using traffic share and network length at link below) BEAR - *http://www.transport.gov.scot/road/maintenance/operating-companies* Transport Scotland Traffic Datasets - *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*

aGVA Existing Data

Parameter	Data Source
GVA per head for Freight and PT	SABS data - GVA per head for SIC code 49 (Land Transport and Transport via Pipelines) *http://www.gov.scot/Topics/Statistics/Browse/Business/SABS/ScotDiv*
GVA per head for C&M	SABS data - GVA per head for SIC code 42 (Civil Engineering) *http://www.gov.scot/Topics/Statistics/Browse/Business/SABS/ScotDiv*
Total employment numbers for Freight	Employment total of 37,000 for road freight analysis from 2013, which was supplied by Transport Scotland
Total employment numbers for PT	Employment total of 18,300 for 2010/11 which was supplied by Transport Scotland. This figure was used because the DfT publication of staff employed by local bus operators for Scotland has not changed between 2010/11 and 2015/16.
Total employment numbers for C&M	SABS data - Employment total for SIC code 42 (Civil engineering) *http://www.gov.scot/Topics/Statistics/Browse/Business/SABS/ScotDiv*

Per capita aGVA screen

Value of the Trunk Road Network (TRN) to Society and the Economy - VaTSE

Analysis: Base case

Per Capita aGVA

This sheet contains the calculations for Per Capita aGVA. This is derived automatically from the aGVA calculations and no user input is required. The calculation is given by:

Per Capita aGVA = aGVA / Total Employment (for each sector)

Freight

Parameter	Unit	Analysis
Total employment	No.	24,420
aGVA	£	1,021,464,180

Public Transport (PT)

Parameter	Unit	Analysis
Total employment	No.	4,941
aGVA	£	206,677,089

Construction & Maintenance (C&M)

Parameter	Unit	Analysis
Total employment	No.	2,000
aGVA	£	151,753,621

Per Capita aGVA Summary Table

Parameter	Unit	Analysis
Freight	£	41,829
Public Transport (PT)	£	41,829
Construction & Maintenance (C&M)	£	75,877
Total of all sectors	**£**	**44,000**

Tax receipts screen

Value of the Trunk Road Network (TRN) to Society and the Economy - VaTSE

Analysis: Base case

Tax Receipts

This sheet contains the calculations for tax receipts. Existing data between 2010 and 2014 is provided where it is available (see the table below for the data sources).

The calculations of PAYE, Corporation tax and VAT are based on a proxy given by the total employment and the percentage share of the employment for the three sectors (Freight, PT and C&M). The calculations for the percentage shares are:

% of total PAYE for Scotland applicable for each sector = (Total Compensation of Employees in Scotland for each sector / Total Compensation of Employees for Scotland)* 100
% of total Corporation Tax for Scotland applicable for each sector = ((Gross Operating Surplus for each sector) / (Total Gross Operating Surplus for Scotland)*100
% of total VAT for Scotland applicable for each sector = (Total GVA for each sector / Total GVA for Scotland) * 100

The total PAYE, Corporation Tax and VAT for the three sectors was calculated as a proportion of the total for Scotland

Total PAYE for Scotland applicable for each sector = (% of total PAYE for Scotland applicable for each sector * Total PAYE for Scotland) / 100
Total Corporation Tax applicable for each sector = (% of total Corporation Tax for Scotland applicable for each sector * Total Corporation Tax for Scotland) / 100
Total VAT applicable for each sector = (% of total VAT for Scotland applicable for each sector * Total VAT for Scotland) / 100

The PAYE, Corporation Tax and VAT per employee for each sector was calculated using the employment totals

Total PAYE per employee for Scotland applicable for each sector = Total PAYE for Scotland applicable for each sector / Total employment in Scotland for each sector
Total Corporation Tax per employee for Scotland applicable for each sector = Total Corporation Tax for Scotland applicable for each sector / Total employment in Scotland for each sector
Total VAT per employee for Scotland applicable for each sector = Total VAT for Scotland applicable for each sector / Total employment in Scotland for each sector

The total PAYE, Corporation Tax and VAT for the TRN was calculated by multiplying the PAYE, Corporation Tax and VAT per employee by employment numbers for the TRN for the three sectors.

Total PAYE for Scotland's TRN applicable for each sector = Total PAYE per employee for Scotland applicable for each sector * Total employment on the TRN for each sector
Total Corporation Tax for Scotland's TRN applicable for each sector = Total Corporation Tax per employee for Scotland applicable for each sector * Total employment on the TRN for each sector
Total VAT for Scotland's TRN applicable for each sector = Total VAT per employee for Scotland applicable for each sector * Total employment on the TRN for each sector

The calculation of tax receipts is a summation of the PAYE, Corporation Tax and VAT for each of the three sectors.

Total Tax Receipts = PAYE + Corporation Tax + VAT

Key
User to enter value
Existing data

Data required for all tax receipt calculations (2013 proxies)

Parameter	Unit	Analysis	Existing Data				
			2014	2013	2012	2011	2010
Total Compensation of Employees for Scotland (PAYE Proxy)	£	69,497,500,000		69,497,500,000			
Total Gross Operating Surplus for Scotland (Corporation Tax	£	51,425,700,000		51,425,700,000			
Total GVA for Scotland (VAT Proxy)	£	122,401,800,000		122,401,800,000			
PAYE for Scotland	£	11,735,000,000	11,735,000,000	11,277,000,000	11,022,000,000	11,127,000,000	11,012,000,000
Corporation Tax for Scotland	£	2,920,000,000	2,920,000,000	2,566,000,000	2,551,000,000	2,424,000,000	2,598,000,000
VAT for Scotland	£	10,734,000,000	10,734,000,000	10,368,000,000	9,754,000,000	9,517,000,000	8,507,000,000
Total employment in Land Transport and Transport via Pipelines	No.	38,100	44,900	38,100	40,000	46,400	45,900
Total employment in (all roads) PT	No.	18,300					18,300
Total employment in Construction	No.	123,300	129,700	123,300			
% of (all roads) Freight employment on TRN	%	66					
% of (all roads) PT employment on TRN	%	27					
% of (all roads) C&M employment on TRN	%	13					

PAYE - Data required for Freight calculations

Parameter	Unit	Analysis	Existing Data				
			2014	2013	2012	2011	2010
Total Compensation of Employees from Land Transport and Transport via Pipelines	£	1,312,800,000		1,312,800,000			

PAYE - Freight

Parameter	Unit	Analysis
% of total PAYE applicable to Freight only	%	1.89
Total PAYE from Freight	£	221,672,837
PAYE for Freight per employee	£	5,818
Total employment in Freight on the TRN	No.	24,420
Total PAYE for Freight on TRN	**£**	**142,080,070**

PAYE - Data required for PT calculations

Parameter	Unit	Analysis
Total Compensation of Employees from Land Transport and Transport via Pipelines	£	1,312,800,000

PAYE - PT

Parameter	Unit	Analysis
% of total PAYE applicable to PT only	%	1.89
Total PAYE from PT	£	221,672,837
PAYE from PT per employee	£	5,818
Total employment for PT on the TRN	No.	4,941
Total PAYE for PT on TRN	**£**	**28,747,651**

PAYE - Data required for C&M calculations

Parameter	Unit	Analysis	Existing Data				
			2014	2013	2012	2011	2010
Total Compensation of Employees from Construction	£	4,949,000,000		4,949,000,000			

PAYE - C&M

Parameter	Unit	Analysis
% of total PAYE applicable to C&M only	%	7.12
Total PAYE from C&M	£	835,663,369
PAYE from C&M per employee	£	6,777
Total employment from C&M on the TRN	No.	2,000
Total PAYE for C&M on TRN	**£**	**13,554,927**

Corporation Tax - Data required for freight calculations

Parameter	Unit	Analysis	Existing Data				
			2014	2013	2012	2011	2010
Total Gross Operating Surplus from Land Transport and Transport via Pipelines	£	609,400,000		609,400,000			

Corporation Tax - Freight

Parameter	Unit	Analysis
% of total Corporation Tax applicable to freight only	%	1.19
Total Corporation Tax for freight for Scotland	£	34,602,310
Corporation Tax for freight per employee for Scotland	£	908
Total employment for freight on the TRN (using Transport Scotland data)	No.	24,420
Total Corporation Tax for freight on TRN	**£**	**22,178,173**

Corporation Tax - Data required for PT calculations

Parameter	Unit	Analysis
Total Gross Operating Surplus from Land Transport and Transport via Pipelines	£	609,400,000

Corporation Tax - PT

Parameter	Unit	Analysis
% of total Corporation Tax total applicable to PT only	%	1.19
Total Corporation Tax for PT	£	34,602,310
Corporation Tax for PT per employee	£	908
Total employment for PT on the TRN	No.	4,941
Total Corporation Tax for PT on TRN	**£**	**4,487,402**

Corporation Tax - Data required for C&M calculations

Parameter	Unit	Analysis	Existing Data				
			2014	2013	2012	2011	2010
Total Gross Operating Surplus from Construction	£	2,749,400,000		2,749,400,000			

Corporation Tax - C&M

Parameter	Unit	Analysis
% of total Corporation Tax total applicable to C&M only	%	5.35
Total Corporation Tax for C&M	£	156,113,539
Corporation Tax for C&M per employee	£	1,266
Total employment for C&M on the TRN	No.	2,000
Total Corporation Tax for C&M on TRN	**£**	**2,532,249**

VAT - Data required for Freight calculations

Parameter	Unit	Analysis	Existing Data				
			2014	2013	2012	2011	2010
Total GVA from Land Transport and Transport via Pipelines	£	1,968,400,000		1,968,400,000			

VAT - Freight

Parameter	Unit	Analysis
% of total VAT applicable to freight only	%	1.61
Total VAT from Freight	£	172,618,422
VAT from Freight per employee	£	4,531
Total employment from Freight on the TRN	No.	24,420
Total VAT from Freight on TRN	**£**	**110,638,894**

VAT - Data required for PT calculations

Parameter	Unit	Analysis
Total GVA from Land Transport and Transport via Pipelines	£	1,968,400,000

VAT - PT

Parameter	Unit	Analysis
% of total VAT applicable to PT only	%	1.61
Total VAT for PT for Scotland	£	172,618,422
VAT for PT per employee for Scotland	£	4,531
Total employment for PT on the TRN	No.	4,941
Total VAT for PT on TRN	**£**	**22,386,027**

VAT - Data required for C&M calculations

Parameter	Unit	Analysis	Existing Data				
			2014	2013	2012	2011	2010
Total GVA from construction	£	7,771,200,000		7,771,200,000			

VAT - C&M

Parameter	Unit	Analysis
% of total VAT applicable to C&M only	%	6.35
Total VAT for C&M for Scotland	£	681,493,743
VAT for C&M per employee for Scotland	£	5,527
Total employment for C&M for Scotland	No.	2,000
Total VAT for C&M on TRN	**£**	**11,054,210**

Summary Table for Tax Receipts

Parameter	Unit	Analysis
PAYE	£ million	184
Corporation Tax	£ million	29
VAT	£ million	144
Total	**£ million**	**358**

Tax Receipts Data Sources

Parameter	Data Source
Total Compensation of Employees (used as a proxy for PAYE)	Input/Output data - Total labour costs for SIC code 41-43 - Construction (used for C&M) and SIC code 49 - Land Transport and Transport via Pipelines (used for freight and PT) *http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output*
Total Gross Operating Surplus (used as a proxy for corporation tax)	Input/Output data - Total Gross Operating Surplus for SIC code 41-43 - Construction (used for C&M) and SIC code 49 - Land Transport and Transport via Pipelines (used for freight and PT) *http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output*
Total GVA (used as a proxy for VAT)	Input/Output data - Total GVA for SIC code 41-43 - Construction (used for C&M) and SIC code 49 - Land Transport and Transport via Pipelines (used for freight and PT) *http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output*
PAYE for Scotland	GERS Spreadsheets *http://www.gov.scot/Topics/Statistics/Browse/Economy/GERS/GERS2016xls*
Corporation Tax for Scotland	
VAT for Scotland	
Total employment numbers for (all) Freight	SABS data for all freight employment total of 38,100 includes rail and other components to match the PAYE value which is all freight
Total employment numbers for (all road) PT	Employment total of 18,300 for 2010/11 which was supplied by Transport Scotland. This figure was used because the DfT publication of staff employed by local bus operators for Scotland has not changed between 2010/11 and 2015/16.
Total employment numbers for (all road) Construction	SABS data - Employment total for SIC code 41-43 (Construction) of 123,300 *http://www.gov.scot/Topics/Statistics/Browse/Business/SABS/ScotDiv*
% of Freight employment for the TRN	Set at 66% to reflect the % of total HGV vehicle kilometres on TRN in 2014 *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*
% of PT employment for bus and coach drivers for the TRN	Set at 27% to reflect the total bus traffic on the TRN in 2014 *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*
% of civil engineering employment for the TRN	Set at 13.245% to produce an employment total of 2,000 for the TRN. The value of 2,000 is made up of two figures - 1,300 (from BEAR at link below) and 700 (Weighted value of UK wide employment for construction of roads and motorways (SIC code 42.11) for Scotland TRN using traffic share and network length at link below) BEAR - *http://www.transport.gov.scot/road/maintenance/operating-companies* Transport Scotland Traffic Datasets - *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*

Tax Receipts Existing Data

Parameter	Data Source
Total Compensation of Employees (used as a proxy for PAYE)	Input/Output data - Total labour costs for SIC code 41-43 - Construction (used for C&M) and SIC code 49 - Land Transport and Transport via Pipelines (used for freight and PT) *http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output*
Total Gross Operating Surplus (used as a proxy for corporation tax)	Input/Output data - Total Gross Operating Surplus for SIC code 41-43 - Construction (used for C&M) and SIC code 49 - Land Transport and Transport via Pipelines (used for freight and PT) *http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output*
Total GVA (used as a proxy for VAT)	Input/Output data - Total GVA for SIC code 41-43 - Construction (used for C&M) and SIC code 49 - Land Transport and Transport via Pipelines (used for freight and PT) *http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output*
PAYE for Scotland	GERS Spreadsheets *http://www.gov.scot/Topics/Statistics/Browse/Economy/GERS/GERS2016xls*
Corporation Tax for Scotland	
VAT for Scotland	
Total employment numbers for (all) Freight	SABS data for all freight employment total of 38,100 includes rail and other components to match the PAYE value which is all freight
Total employment numbers for (all road) PT	Employment total of 18,300 for 2010/11 which was supplied by Transport Scotland. This figure was used because the DfT publication of staff employed by local bus operators for Scotland has not changed between 2010/11 and 2015/16.
Total employment numbers for (all road) Construction	SABS data - Employment total for SIC code 41-43 (Construction) of 123,300 *http://www.gov.scot/Topics/Statistics/Browse/Business/SABS/ScotDiv*

Traffic screen

Value of the Trunk Road Network (TRN) to Society and the Economy - VaTSE

Analysis: Base case

Traffic data

The traffic data on this sheet is used for the RTAs, travel time and CO_2 emissions analyses.
Table 1 is the traffic (in million vehicle kilometres) split between road type and vehicle type

Key: User to enter value | Existing data

Table 1 - Traffic in million vehicle kilometres split by road type and vehicle type

Road Type	Unit	Analysis						Existing Data 2014						
		Cars	Two wheeled motor vehicles	Buses	Light goods vehicles	Heavy goods vehicles	All motor vehicles	Cars	Two wheeled motor vehicles	Buses	Light goods vehicles	Heavy goods vehicles	All motor vehicles	Pedal Cycles*
Motorways	Million vehicle km	5,437	29	65	1,076	814	7,421	5,437	29	65	1,076	814	7,421	0
Trunk 'A' roads - Urban	Million vehicle km	750	4	8	139	62	963	750	4	8	139	62	963	1
Trunk 'A' roads - Rural	Million vehicle km	6,514	69	91	1,275	764	8,713	6,514	69	91	1,275	764	8,713	4
Non-trunk 'A' roads - Urban	Million vehicle km	3,658	19	98	549	132	4,456	3,658	19	98	549	132	4,456	23
Non-trunk 'A' roads - Rural	Million vehicle km	6,051	64	104	1,203	420	7,842	6,051	64	104	1,203	420	7,842	15
Total of all major roads	Million vehicle km	22,410	185	366	4,242	2,192	29,395	22,410	185	366	4,242	2,192	29,395	43
Minor roads - Urban	Million vehicle km	6,573	50	181	1,114	107	8,025	6,573	50	181	1,114	107	8,025	124
Minor roads - Rural	Million vehicle km	5,415	62	63	1,317	174	7,031	5,415	62	63	1,317	174	7,031	173
Total of all minor roads	Million vehicle km	11,988	112	244	2,431	281	15,056	11,988	112	244	2,431	281	15,056	297
Total all Roads	**Million vehicle km**	**34,398**	**297**	**610**	**6,673**	**2,473**	44,451	**34,398**	**297**	**610**	**6,673**	**2,473**	44,451	**340**
TRN total	Million vehicle km	**12,701**	**102**	**164**	**2,490**	**1,640**	**17,097**	**12,701**	**102**	**164**	**2,490**	**1,640**	**17,097**	**5**
Non-TRN total	Million vehicle km	**21,697**	**195**	**446**	**4,183**	**833**	**27,354**	**21,697**	**195**	**446**	**4,183**	**833**	**27,354**	**335**

* Note - For 2014 pedal cycle numbers are available but not used in the analysis. The data is not available for earlier years.

Table 2 shows the split of traffic (in million vehicle kilometres) by road type between 2010 and 2014.

Table 2 - Traffic in million vehicle kilometres split by road type

Road Type	Unit	Analysis	Existing Data				
			2014	2013	2012	2011	2010
Motorways	Million vehicle km	7,421	7,421	7,262	7,140	6,570	6,503
Trunk 'A' roads - Urban	Million vehicle km	963	963	960	973	951	945
Trunk 'A' roads - Rural	Million vehicle km	8,713	8,713	8,766	8,678	8,793	8,773
Non-trunk 'A' roads - Urban	Million vehicle km	4,456	4,456	4,390	4,395	4,471	4,522
Non-trunk 'A' roads - Rural	Million vehicle km	7,842	7,842	7,670	7,666	7,781	7,752
Total of all major roads	Million vehicle km	**29,395**	**29,395**	**29,048**	**28,852**	**28,566**	**28,495**
Minor roads - Urban	Million vehicle km	8,025	8,025	7,960	8,067	8,016	7,978
Minor roads - Rural	Million vehicle km	7,031	7,031	6,832	6,630	6,809	7,014
Total of all minor roads	Million vehicle km	**15,056**	**15,056**	**14,792**	**14,697**	**14,825**	**14,992**
Total of all roads	**Million vehicle km**	**44,451**	**44,451**	**43,840**	**43,549**	**43,391**	**43,487**
TRN total	Million vehicle km	**17,097**	**17,097**	**16,988**	**16,791**	**16,314**	**16,221**
Non-TRN total	Million vehicle km	**27,354**	**27,354**	**26,852**	**26,758**	**27,077**	**27,266**

The RTA, travel time and CO_2 emission calculations are based on the TRN traffic moving to the non-TRN. This redistribution is based on percentages entered in the table below. Note that the total percentage of TRN traffic redistributed does not have to add up to 100% but a warning is provided if the redistributed traffic is less than 100%.

Redistribution of TRN traffic

TRN	Unit	Non-TRN				
		Non-TRN 'A' Urban	Non-TRN 'A' Rural	Minor urban	Minor rural	Total
Motorway	%	50	50	0	0	100
TRN 'A' Urban	%	95		5		100
TRN 'A' Rural	%		95		5	100

WARNING	
0	% of TRN journeys not redistributed
0	% of TRN journeys not redistributed
0	% of TRN journeys not redistributed

Traffic Data Sources

Parameter	Data Source
Traffic in million vehicle kilometres on TRN and non-TRN	Chapter 05, Sheet T5.1 and Sheet T5.2-5.3 from Scottish Transport Statistics No 34 - Datasets *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*
% of redistributed traffic from TRN to the non-TRN	Assumed redistribution agreed with Transport Scotland. No data to support the values used.

Traffic Existing Data

Parameter	Data Source
Traffic in million vehicle kilometres on TRN and non-TRN	Chapter 05, Sheet T5.1 and Sheet T5.2-5.3 from Scottish Transport Statistics No 34 - Datasets *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*

RTA screen

Value of the Trunk Road Network (TRN) to Society and the Economy - VaTSE

Analysis: Base case

Road Traffic Accident (RTA) Costs

This sheet contains the calculations of RTAs for traffic on the TRN and non-TRN. Existing accident data from Transport Scotland (2010-2014) and NESA (2010) is shown in the purple cells. Where data is not available for a year then the cell is blank. The cells coloured yellow show where data is needed for the analysis.

Note - Traffic data is entered on the "Traffic" sheet.

The costs of RTAs on the TRN and non-TRN are calculated by:

Total cost of RTAs by road type per million vehicle km = No. of accidents (by type) * Cost of accident (by type) / Traffic (by road type)

Key

User to enter value | Existing data

Data for calculating the cost of RTAs

Parameter	Unit	Analysis	Existing Data				
Traffic on TRN	Million vehicle km	17,097					
Traffic on non-TRN	Million vehicle km	27,354					
Motorway traffic on non-TRN after redistribution	Million vehicle km	7,421					
TRN 'A' urban road traffic on non-TRN after redistribution	Million vehicle km	963					
TRN 'A' rural road traffic on non-TRN after redistribution	Million vehicle km	8,713					
Total TRN traffic on non-TRN after redistribution	Million vehicle km	17,097					
Accidents			2014	2013	2012	2011	2010
No. of fatal accidents TRN	No.	57	57	61	37	52	57
No. of fatal accidents non-TRN	No.	121	121	98	127	123	132
No. of serious accidents TRN	No.	236	236	228	267	272	324
No. of serious accidents non-TRN	No.	1,250	1,250	1,202	1,467	1,404	1,389
Cost of fatal accidents on all roads (Transport Scotland Data)	£		2,171,848	1,990,632	1,951,042	1,938,455	1,855,013
Cost of serious accidents on all roads (Transport Scotland Data)	£		239,383	230,156	224,578	214,563	205,303
Cost of fatal accidents on all roads (NESA Data)	£						1,730,651
Cost of serious accidents on all roads (NESA Data)	£						215,896
Cost of fatal accidents on all roads	£	2,171,848					
Cost of serious accidents on all roads	£	239,383					

Summary Table for RTA Costs

Parameter	Unit	Analysis
TRN - Total cost of fatal accidents	£ per million vehicle km	7,241
TRN - Total cost of serious accidents	£ per million vehicle km	3,304
TRN - Total cost of fatal and serious accidents	£ per million vehicle km	10,545
Non-TRN - Number of fatal accidents	per million vehicle km	0.004423
Non-TRN - Number of serious accidents	per million vehicle km	0.045697
Non-TRN - Total number of fatal and serious accidents	per million vehicle km	0.050121
Non-TRN - Cost of fatal accidents for redistributed traffic	£ million	164
Non-TRN - Cost of serious accidents for redistributed traffic	£ million	187
Non-TRN - Total cost of accidents for redistributed traffic	£ million	351
Total RTA savings from fatal accidents on the TRN*	**£ million**	40
Total RTA savings from serious accidents on the TRN*	**£ million**	131
Total RTA savings from all accidents on the TRN*	**£ million**	171

* Note - Reductions in cost are shown as positive values. Increases in cost are shown as negative numbers.

RTAs Data Sources

Parameter	Data Source
No. of accidents per road type	Fatal and serious accidents on TRN, data provided by Transport Scotland *http://www.transport.gov.scot/statistics/j397988-011.htm*
Cost of fatal and serious accidents on all roads (Transport Scotland Data) *2014 using 2014 prices*	Table 10 (p87) in "Reported Road Casualties Scotland 2014 - A National Statistics Publication for Scotland" *http://www.transport.gov.scot/statistics/j397988-000.htm*

RTAs Existing Data

Parameter	Data Source
No. of accidents per road type	Fatal and serious accidents on TRN, data provided by Transport Scotland *http://www.transport.gov.scot/statistics/j397988-011.htm*
Cost of fatal and serious accidents on all roads (Transport Scotland Data) *2014 using 2014 prices*	Table 10 (p87) in "Reported Road Casualties Scotland 2014 - A National Statistics Publication for Scotland" *http://www.transport.gov.scot/statistics/j397988-000.htm*
Cost of fatal and serious accidents on all roads (Transport Scotland Data) *2013 using 2013 prices*	Table 10 (p101) in "Reported Road Casualties Scotland 2013 - A National Statistics Publication for Scotland" *http://www.transport.gov.scot/statistics/j340611-00.htm*
Cost of fatal and serious accidents on all roads (Transport Scotland Data) *2012 using 2012 prices*	Table 10 (p107) in "Reported Road Casualties Scotland 2012 - A National Statistics Publication for Scotland" *http://www.transport.gov.scot/statistics/j285660-00.htm*
Cost of fatal and serious accidents on all roads (Transport Scotland Data) *2011 using 2010 prices*	Table 10 (p127) in "Reported Road Casualties Scotland 2011 - A National Statistics Publication for Scotland" *http://www.transport.gov.scot/statistics/j245189-00.htm*
Cost of fatal and serious accidents on all roads (Transport Scotland Data) *2010 using 2009 prices*	Table 10 (p107) in "Reported Road Casualties Scotland 2010 - A National Statistics Publication for Scotland" *http://www.transport.gov.scot/statistics/j199237-00.htm*
Cost of fatal and serious accidents on all roads (NESA Data) *2010 using 2010 prices*	Table 6/4/1 (p129) in "Volume 15 - Economic assessment of road schemes in Scotland, Section 1 - The NESA Manual" *http://sias.com/2013/TS/The%20NESA%20Manual%20-%20October%202015.pdf*

Travel time screen

Value of the Trunk Road Network (TRN) to Society and the Economy - VaTSE

Analysis: Base case

Cost of Travel Time

Travel time is calculated by the change in time travelling the same distance on the TRN compared to using the non-TRN. TRN traffic is redistributed on to the non-TRN as shown in the Traffic worksheet.

Note - Traffic data is entered on the "Traffic" sheet.

Key	
	User to enter value

Data for redistribution of traffic

Road Type	Unit	Cars	Two wheeled motor vehicles	Buses	Light goods vehicles	Heavy goods vehicles	All motor vehicles
Motorways	Million vehicle km	5,437	29	65	1,076	814	7,421
Trunk 'A' roads - Urban	Million vehicle km	750	4	8	139	62	963
Trunk 'A' roads - Rural	Million vehicle km	6,514	69	91	1,275	764	8,713
Non-trunk 'A' roads - Urban	Million vehicle km	3,658	19	98	549	132	4,456
Non-trunk 'A' roads - Rural	Million vehicle km	6,051	64	104	1,203	420	7,842
Total of all major roads	Million vehicle km	22,410	185	366	4,242	2,192	29,395
Minor roads - Urban	Million vehicle km	6,573	50	181	1,114	107	8,025
Minor roads - Rural	Million vehicle km	5,415	62	63	1,317	174	7,031
Total of all minor roads	Million vehicle km	11,988	112	244	2,431	281	15,056
All Roads	**Million vehicle km**	**34,398**	**297**	**610**	**6,673**	**2,473**	**44,451**

Percentages for the redistribution of traffic from the TRN to the non-TRN (See the "Traffic" worksheet)

Road Type	Unit	Non-TRN				
		A' Urban	A' Rural	Minor urban	Minor rural	Total
Motorway	%	50	50	0	0	100
TRN 'A' Urban	%	95		5		100
TRN 'A' Rural	%		95		5	100

Redistribution of TRN traffic on to non-trunk A roads and minor roads

TRN road type	Traffic redistributed to	% redistributed	Unit	Cars	Two wheeled motor vehicles	Buses	Light goods vehicles	Heavy goods vehicles	All motor vehicles
Motorway	Non-trunk 'A' roads urban	50	Million vehicle km	2,719	15	33	538	407	3,711
Motorway	Non-trunk 'A' roads rural	50	Million vehicle km	2,719	15	33	538	407	3,711
Motorway	Minor roads urban	0	Million vehicle km	0	0	0	0	0	0
Motorway	Minor roads rural	0	Million vehicle km	0	0	0	0	0	0
TRN 'A' urban	Non-trunk 'A' roads urban	95	Million vehicle km	713	4	8	132	59	915
TRN 'A' urban	Minor roads urban	5	Million vehicle km	38	0	0	7	3	48
TRN 'A' rural	Non-trunk 'A' roads rural	95	Million vehicle km	6,188	66	86	1,211	726	8,277
TRN 'A' rural	Minor roads rural	5	Million vehicle km	326	3	5	64	38	436

The following two tables show:
A) The current use of the TRN
B) Redistributed traffic from the TRN (using values from table above)

A) Current use of the TRN

Road Type	Unit	Cars	Two wheeled motor vehicles	Buses	Light goods vehicles	Heavy goods vehicles	All motor vehicles
Motorways	Million vehicle km	5,437	29	65	1,076	814	7,421
Trunk 'A' roads - Urban	Million vehicle km	750	4	8	139	62	963
Trunk 'A' roads - Rural	Million vehicle km	6,514	69	91	1,275	764	8,713
Total	Million vehicle km	12,701	102	164	2,490	1,640	**17,097**

B) Redistributed TRN traffic

Road Type	Unit	Cars	Two wheeled motor vehicles	Buses	Light goods vehicles	Heavy goods vehicles	All motor vehicles
Non-trunk 'A' roads - Urban	Million vehicle km	3,431	18	40	670	466	4,625
Non-trunk 'A' roads - Rural	Million vehicle km	8,907	80	119	1,749	1,133	11,988
Minor roads - Urban	Million vehicle km	38	0	0	7	3	48
Minor roads - Rural	Million vehicle km	326	3	5	64	38	436
Total	Million vehicle km	12,701	102	164	2,490	1,640	**17,097**

Journey time

Journey times are calculated for the current use of the TRN and redistributed TRN traffic using the average freeflow speeds in the Table below

Total journey time = Traffic in million vehicle km (by road type) / speed (by road type)

Data for freeflow traffic speeds on major and minor roads

Road Type	Unit	Cars	Two wheeled motor vehicles	Buses	Light goods vehicles	Heavy goods vehicles
Motorways	km/h	112	112	96	96	88
Trunk 'A' roads - Urban	km/h	80	80	48	48	48
Trunk 'A' roads - Rural	km/h	96	96	64	64	80
Non-trunk 'A' roads - Urban	km/h	48	48	40	40	40
Non-trunk 'A' roads - Rural	km/h	80	80	48	48	48
Minor roads - Urban	km/h	48	48	32	48	32
Minor roads - Rural	km/h	64	64	48	64	40

Using the redistributed traffic, the following two tables for journey time show:
C) Journey time for the current use of the TRN
D) Journey time for the redistributed traffic from the TRN

C) Total Journey Time - Current use of the TRN

Road Type	Unit	Cars	Two wheeled motor vehicles	Buses	Light goods vehicles	Heavy goods vehicles
Motorways	Million hours	48.54	0.26	0.68	11.21	9.25
Trunk 'A' roads - Urban	Million hours	9.38	0.05	0.17	2.90	1.29
Trunk 'A' roads - Rural	Million hours	67.85	0.72	1.42	19.92	9.55
Total	Million hours	125.77	1.03	2.27	34.03	20.09

D) Total Journey Time - Redistributed TRN traffic

Road Type	Unit	Cars	Two wheeled motor vehicles	Buses	Light goods vehicles	Heavy goods vehicles
Non-trunk 'A' roads - Urban	Million hours	71.48	0.38	1.00	16.75	11.65
Non-trunk 'A' roads - Rural	Million hours	111.34	1.00	2.48	36.44	23.60
Minor roads - Urban	Million hours	0.78	0.00	0.01	0.14	0.10
Minor roads - Rural	Million hours	5.09	0.05	0.09	1.00	0.96
Total	Million hours	188.68	1.44	3.59	54.33	36.30

Value of time

Parameter	Unit	Cars	Two wheeled motor vehicles	Buses	Light goods vehicles	Heavy goods vehicles
Value of time	£ per hour	14.48	21.87	108.37	15.72	16.16

The calculation of change in travel time by vehicle type is:

Total delay time (million hours) = Total journey time of redistributed traffic from TRN - Total journey time of current use of TRN

Travel time cost = Delay time (by vehicle type) * Value of time (by vehicle type)

Summary table for time savings

Parameter	Unit	Cars	Two wheeled motor vehicles	Buses	Light goods vehicles	Heavy goods vehicles
Delay Time	Million hours	62.91	0.41	1.32	20.31	16.21
Delay Cost	£ million	910.95	9.02	143.30	319.25	261.92

Total travel time cost	**£ million**	**1644.43**

Time Savings Data Sources

Parameter	Data Source
Traffic speed on major and minor roads	Freeflow speeds of major and minor roads
Value of time	WebTAG average values of time per vehicle type using 2014 prices (£ per hour) Values for cars, buses, light goods vehicles and heavy goods vehicles from Sheet A1.3.6 Value for two wheeled motor vehicles not available per vehicle in sheet A1.3.6 of WebTAG so the value per person from sheet A1.3.2 was used instead *https://www.gov.uk/government/publications/webtag-tag-data-book-july-2016*

CO_2 emissions screen

Value of the Trunk Road Network (TRN) to Society and the Economy - VaTSE

Analysis: Base case

Costs of CO_2 Emissions

This sheet contains the calculations for the cost of CO_2 emissions on the TRN compared to the same traffic using the non-TRN roads. Example data data from previous years is provided in the purple cells (see the table below for the data sources). Where data is not available for a year then the cell is blank. The cells coloured yellow represent where data is needed in the analysis.

Note - Traffic data is entered on the "Traffic" sheet.

The split of emissions for TRN urban/rural was calculated by:

TRN (urban or rural) emissions = Road emissions / {Trunk 'A' roads + [Ratio of TRN over non-TRN emissions * (Non-trunk 'A' roads + minor roads)]}

Non-TRN (urban or rural) emissions = TRN emissions * ratio of TRN over non-TRN emissions

Key

User to enter value | Existing data

Data required for all CO_2 emission calculations

Parameter	Unit	Analysis	Existing Data				
			2014	2013	2012	2011	2010
Traffic on the TRN	Million vehicle km	17,097					
Traffic on the non-TRN	Million vehicle km	27,354					
Motorway traffic	Million vehicle km	7,421					
Trunk 'A' roads - Urban	Million vehicle km	963					
Non-Trunk 'A' road - Urban	Million vehicle km	4,456					
Minor roads - Urban	Million vehicle km	8,025					
Trunk 'A' roads - Rural	Million vehicle km	8,713					
Non-Trunk 'A' road - Rural	Million vehicle km	7,842					
Minor roads - Rural	Million vehicle km	7,031					
Urban road emissions	tCO_2e	2,700,000		2,700,000	2,800,000	3,000,000	2,900,000
Rural road emissions	tCO_2e	4,600,000		4,600,000	4,600,000	4,700,000	4,779,000
Motorway emissions	tCO_2e	1,900,000		1,900,000	1,900,000	1,700,000	1,691,000
Non-traded CO_2 emission values (central estimate)	£/t CO_2e	61	61	61	60	59	58

Ratio for split of emissions of non-TRN and TRN*

Parameter	Unit	Analysis
Ratio of emissions of non-TRN and TRN - Urban	tCO_2e per million vehicle km	1.3
Ratio of emissions of non-TRN and TRN - Rural	tCO_2e per million vehicle km	1.3

*Note - The ratios are specified by the user

Totals for split of emissions between road types - TRN

Parameter	Unit	Analysis
Motorway emissions	tCO_2e per million vehicle km	256
TRN - Urban	tCO_2e per million vehicle km	157
TRN - Rural	tCO_2e per million vehicle km	164

Totals for split of emissions between road types - Non-TRN

Parameter	Unit	Analysis
Non-TRN Urban	tCO_2e per million vehicle km	204
Non-TRN Rural	tCO_2e per million vehicle km	213

Percentages for the redistribution of traffic from the TRN to the non-TRN (See the "Traffic" worksheet)

Parameter	Unit	Non-TRN 'A' Urban	Non-TRN 'A' Rural	Minor urban	Minor rural	Total
Motorway	%	50	50	0	0	100
TRN 'A' Urban	%	95		5		100
TRN 'A' Rural	%		95		5	100

Redistributed TRN traffic to Non-TRN roads (million vehicle kilometres)

Parameter	Unit	Non-TRN 'A' Urban	Non-TRN 'A' Rural	Minor urban	Minor rural	Total
Motorway	Million vehicle km	3,631	3,631	0	0	7,262
TRN 'A' Urban	Million vehicle km	912		48		960
TRN 'A' Rural	Million vehicle km		8,328		438.3	8,766
Total	Million vehicle km	**4,543**	**11,959**	**48**	**438**	

Redistributed TRN traffic to Non-TRN roads (emissions)

Parameter	Unit	Non-TRN 'A' Urban	Non-TRN 'A' Rural	Minor urban	Minor rural	Total
Motorway	tCO_2e	741,482	774,154	0	0	1,515,635
TRN 'A' Urban	tCO_2e	186,238		9,802		196,040
TRN 'A' Rural	tCO_2e		1,775,521		93,448	1,868,970
Total	tCO_2e	**927,720**	**2,549,675**	**9,802**	**93,448**	

The summary tables show the split between road types for the CO_2 emissions and the savings between the TRN and redistributed TRN traffic on to non-TRN roads. CO_2 emission cost changes are the differences between the TRN and the redistributed TRN traffic on to non-TRN roads. CO_2 emission costs are calculated by:

CO_2 emissions cost per road type = (CO_2 emissions per road type * traffic per road type) * CO_2 emission value

Summary Table of CO_2 emissions*

Parameter	Unit	'A' Urban	A' Rural	Minor Urban	Minor Rural	Motorway
TRN	tCO_2e	151,272	1,428,977			1,900,000
Redistributed TRN	tCO_2e	927,720	2,549,675	9,802	93,448	
CO_2 emissions (non TRN emissions - (minus) TRN emissions)	tCO_2e	**776,449**	**1,120,698**	**9,802**	**93,448**	**-1,900,000**
CO_2 emission costs (non TRN costs - (minus) TRN costs)	£	**47,363,359**	**68,362,579**	**597,923**	**5,700,358**	**-115,900,000**

Parameter	Unit	Total
Total change in CO_2 of using the TRN over non-TRN	tCO_2e million	0.10
Total change in CO_2 costs of using the TRN over non-TRN	£ million	6

* Note - Reductions in cost are shown as positive values. Increases in cost are shown as negative numbers.

CO_2 Emissions Data Sources

Parameter	Data Source
TRN/Non-TRN CO_2 emissions for 2013	Rural, urban and motorway CO_2 emissions in "Carbon Account for Transport" report by Transport Scotland (2015) *http://www.transport.gov.scot/sites/default/files/documents/rrd_reports/uploaded_reports/j408446/j408446.pdf*
Non-traded Carbon prices and sensitivities (2010-2100) for appraisal	Table 3 used in "Data tables 1-20: supporting the toolkit and the guidance" document *https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal*
Ratio for split of emissions between TRN and non-TRN for Urban and Rural based on Transport Scotland	Value set at 1.3 based on kilometres travelled on TRN rural versus total rural kilometres then the rural trunk road kilometres account for 36%. For this analysis, a 30% ratio was applied (1.3).

CO_2 Emissions Existing Data

Parameter	Data Source
TRN/Non-TRN CO_2 emissions for 2013	Rural, urban and motorway CO_2 emissions in "Carbon Account for Transport" report by Transport Scotland (2015) *http://www.transport.gov.scot/sites/default/files/documents/rrd_reports/uploaded_reports/j408446/j408446.pdf*
TRN/Non-TRN CO_2 emissions for 2012	Rural, urban and motorway CO_2 emissions in "Carbon Account for Transport" report by Transport Scotland (2014) *http://www.transport.gov.scot/system/files/documents/reports/j353802%20.pdf*
TRN/Non-TRN CO_2 emissions for 2011	Rural, urban and motorway CO_2 emissions in "Carbon Account for Transport" report by Transport Scotland (2013/14) *http://www.transport.gov.scot/sites/default/files/documents/rrd_reports/uploaded_reports/j317395/j317395.pdf*
TRN/Non-TRN CO_2 emissions for 2010	Rural, urban and motorway CO_2 emissions in "Carbon Account for Transport" report by Transport Scotland (2012) *http://www.transport.gov.scot/sites/default/files/documents/rrd_reports/uploaded_reports/j254327/j254327.pdf*
Non-traded Carbon prices and sensitivities (2010-2100) for appraisal	Table 3 used in "Data tables 1-20: supporting the toolkit and the guidance" document *https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal*

Appendix E Data sources for the base case analysis

aGVA Data Sources

Parameter	Data Source
GVA per head for Freight and PT	SABS data - GVA per head for SIC code 49 (Land Transport and Transport via Pipelines) *http://www.gov.scot/Topics/Statistics/Browse/Business/SABS/ScotDiv*
GVA per head for C&M	SABS data - GVA per head for SIC code 42 (Civil Engineering) *http://www.gov.scot/Topics/Statistics/Browse/Business/SABS/ScotDiv*
Total employment numbers for Freight	Employment total of 37,000 for road freight analysis from 2013, which was supplied by Transport Scotland
Total employment numbers for PT	Employment total of 18,300 for 2010/11 which was supplied by Transport Scotland. This figure was used because the DfT publication of staff employed by local bus operators for Scotland has not changed between 2010/11 and 2015/16.
Total employment numbers for C&M	SABS data - Employment total for SIC code 42 (Civil engineering) *http://www.gov.scot/Topics/Statistics/Browse/Business/SABS/ScotDiv*
% of Freight employment for the TRN	Set at 66% to reflect the percentage of total HGV vehicle kilometres on TRN in 2014 *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*
% of PT employment for bus and coach drivers for the TRN	Set at 27% to reflect the total bus traffic on the TRN in 2014 *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*
% of civil engineering employment for the TRN	Set at 13.245% to produce an employment total of 2,000 for the TRN. The value of 2,000 is made up of two figures - 1,300 (from BEAR at link below) and 700 (Weighted value of UK wide employment for construction of roads and motorways (SIC code 42.11) for Scotland TRN using traffic share and network length at link below) BEAR - *http://www.transport.gov.scot/road/maintenance/operating-companies* Transport Scotland Traffic Datasets - *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*

Tax Receipts Data Sources

Parameter	Data Source
Total Compensation of Employees (used as a proxy for PAYE)	Input/Output data - Total labour costs for SIC code 41-43 - Construction (used for C&M) and SIC code 49 - Land Transport and Transport via Pipelines (used for freight and PT) *http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output*
Total Gross Operating Surplus (used as a proxy for corporation tax)	Input/Output data - Total Gross Operating Surplus for SIC code 41-43 - Construction (used for C&M) and SIC code 49 - Land Transport and Transport via Pipelines (used for freight and PT) *http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output*
Total GVA (used as a proxy for VAT)	Input/Output data - Total GVA for SIC code 41-43 - Construction (used for C&M) and SIC code 49 - Land Transport and Transport via Pipelines (used for freight and PT) *http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output*
PAYE for Scotland	GERS Spreadsheets *http://www.gov.scot/Topics/Statistics/Browse/Economy/GERS/GERS2016xls*
Corporation Tax for Scotland	
VAT for Scotland	
Total employment numbers for (all) Freight	SABS data for all freight employment total of 38,100 includes rail and other components to match the PAYE value which is all freight.

Parameter	Data Source
Total employment numbers for (all road) PT	Employment total of 18,300 for 2010/11 which was supplied by Transport Scotland. This figure was used because the DfT publication of staff employed by local bus operators for Scotland has not changed between 2010/11 and 2015/16.
Total employment numbers for (all road) Construction	SABS data - Employment total for SIC code 41-43 (Construction) of 123,300 *http://www.gov.scot/Topics/Statistics/Browse/Business/SABS/ScotDiv*
% of Freight employment for the TRN	Set at 66% to reflect the percentage of total HGV vehicle kilometres on TRN in 2014 *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*
% of PT employment for bus and coach drivers for the TRN	Set at 27% to reflect the total bus traffic on the TRN in 2014 *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*
% of civil engineering employment for the TRN	Set at 13.245% to produce an employment total of 2,000 for the TRN. The value of 2,000 is made up of two figures - 1,300 (from BEAR at link below) and 700 (Weighted value of UK wide employment for construction of roads and motorways (SIC code 42.11) for Scotland TRN using traffic share and network length at link below) BEAR - *http://www.transport.gov.scot/road/maintenance/operating-companies* Transport Scotland Traffic Datasets - *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*

Traffic Values Data Sources

Parameter	Data Source
Traffic in million vehicle kilometres on TRN and non-TRN	Chapter 05, Sheet T5.1 and Sheet T5.2-5.3 from Scottish Transport Statistics No 34 - Datasets *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*
% of redistributed traffic from TRN to the non-TRN	Assumed redistribution agreed with Transport Scotland. No data to support the values used.

RTA Data Sources

Parameter	Data Source
Traffic in million vehicle kilometres on TRN and non-TRN	Chapter 05, Sheet T5.1 and Sheet T5.2-5.3 from Scottish Transport Statistics No 34 - Datasets *http://www.transport.gov.scot/report/scottish-transport-statistics-no-34-datasets-8914*
No. of accidents per road type	Fatal and serious accidents on TRN, data provided by Transport Scotland *http://www.transport.gov.scot/statistics/j397988-011.htm*
Cost of fatal and serious accidents on all roads (Transport Scotland Data) *2014 using 2014 prices*	Table 10 (p87) in "Reported Road Casualties Scotland 2014 - A National Statistics Publication for Scotland" *http://www.transport.gov.scot/statistics/j397988-000.htm*

Time Savings Data Sources

Parameter	Data Source
Traffic speed on major and minor roads	Freeflow speeds of major and minor roads
Value of time	WebTAG average values of time per vehicle type using 2014 prices (£ per hour) Values for cars, buses, light goods vehicles and heavy goods vehicles from Sheet A1.3.6 Value for two wheeled motor vehicles not available per vehicle in sheet A1.3.6 of WebTAG so the value per person from sheet A1.3.2 was used instead *https://www.gov.uk/government/publications/webtag-tag-data-book-july-2016*

CO_2 Savings Data Sources

Parameter	Data Source
TRN/Non-TRN CO_2 emissions for 2013	Rural, urban and motorway CO_2 emissions in "Carbon Account for Transport" report by Transport Scotland (2015) *http://www.transport.gov.scot/sites/default/files/documents/rrd_reports/uploaded_reports/j408446/j408446.pdf*
Non-traded Carbon prices and sensitivities (2010-2100) for appraisal	Table 3 used in "Data tables 1-20: supporting the toolkit and the guidance" document *https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal*
Ratio for split of emissions between TRN and non-TRN for Urban and Rural based on Transport Scotland	Value set at 1.3 based on kilometres travelled on TRN rural versus total rural kilometres then the rural trunk road kilometres account for 36%. For this analysis, a 30% ratio was applied (1.3).

Appendix F Sensitivity testing

Analysis	Parameter to change for sensitivity testing	Base Case	Scenario 1 Increased spend (+25%)	Scenario 2 Decreased Spend (-25%)
aGVA	Freight employment	37,000	46,250	27,750
	C&M employment	2,000	2,500	1,500
	PT employment	18,300	22,875	13,725
	GVA per head for freight and PT	41,829	52,286	31,372
	GVA per head for C&M	75,877	94,846	56,908
Tax Receipts	Freight employment	37,000	46,250	27,750
	C&M employment	2,000	2,500	1,500
	PT employment	18,300	22,875	13,725

The Value of the Trunk Road Network to Society and the Economy in Scotland

Other titles from this subject area

1 Parkman, C. C., Bradbury, T., Peeling, D. and Booth, C. (2012a). "Economic, environmental, and social impact of changes in maintenance spend on local roads in Scotland"

2 Parkman, C.C., Abell, R., Bradbury, T. and Peeling, D. (2012b). "Economic, environmental and social impact of changes in maintenance spend on roads in Scotland – Summary Report"

3 Gould E, Parkman C and Buckland T (2013). "The Economics of Road Maintenance", RAC Foundation,

4 Buckland T, Parkman C, Booth C and Abell R (2015). "Valuing the Benefits of Road Maintenance", CPR2137, TRL, Crowthorne, Prepared for Department for Transport

TRL
Crowthorne House, Nine Mile Ride,
Wokingham, Berkshire, RG40 3GA,
United Kingdom
T: +44 (0) 1344 773131
F: +44 (0) 1344 770356
E: enquiries@trl.co.uk
W: www.trl.co.uk

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