Assessment of Methods for Modelling and Appraisal of the Sub-National, Regional and Local Economy Impacts of Transport

Report to the Department for Transport

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1   Executive Summary

This study was commissioned by the Department for Transport (DfT) to review methods for modelling and appraisal of the sub-national, regional, and local economy impacts of transport.

A number of methods have been used by scheme promoters and others to produce estimates of the impacts on the level and location of economic activity that would be generated from specific transport proposals. This review considers whether methods developed to date (up to July 2013) for estimation of these impacts are suitable for use in their current form, or could be further developed.

Estimates of the sub national economy impacts of transport can be required for considering proposed transport interventions within the DfT's Transport Business Case approach to informing decision making. In this approach, the strategic case considers whether an intervention is supported by a robust case for change that fits with wider public policy objectives. The strategic case can require estimates of metrics such as changes in output, measured through Gross Value Added (GVA) or Gross Domestic Product (GDP), or changes in employment, generated by the intervention. Estimates of sub national economy impacts can also be of interest to local authorities and Local Transport Bodies in England, who have a remit that includes focusing on local economic growth and therefore need to understand the local economic growth impacts of transport.

This review was required to:

- Identify the types of modelling and appraisal methods that could be used for assessing the sub-national, regional, and local economy impacts of transport proposals.

- Develop a set of criteria that can be applied to assess these methods. These criteria should include consideration of the theoretical and practical robustness, feasibility, practicality, and proportionality, and other criteria that the research identifies to be relevant.

- Assess the identified methods against these criteria, identifying the key strengths and limitations of each type of method.

- Provide detailed options for further research to further develop methods for the modelling and appraisal of impacts of transport schemes on sub-national, regional and local economies.

The review identified four broad groups of methods, although in practice the analysis for specific transport proposals may contain elements of several of these methods. The first method is a survey-based approach which estimates how the change in transport provision may impact on local business and economic performance. The method tends to use statistical data for the local area whenever available, combined with evidence gathered from business surveys and interviews, as well as, where available, evaluation evidence of impacts from the implementation of similar schemes elsewhere. While the survey-based method can be applied in a fairly simplistic way, more sophisticated versions have been developed and are set out in the Regeneration Impacts guidance in WebTAG (DfT's transport analysis guidance) and also in the Economic Activity and Location Impacts Analysis guidance published by Transport Scotland.

The second type of method involves modelling the changes in land use that follow from the scheme. This approach is applied in Land Use and Transport Interaction (LUTI) models. Under this approach the effect on zonal accessibility from the transport model is fed into a land-use model with feedback to the

transport model to develop a consistent account of the combined effect of an intervention on the transport and land use system.

The third category of methods considers the impacts transport schemes can have in improving connectivity. There is evidence that increased transport connectivity is correlated with increased productivity and employment density. This "wage equation" approach is based on the relationships between transport connectivity and productivity, and between transport connectivity and employment density.

The fourth category, Spatial Computable General Equilibrium (SCGE) models, attempts to provide a comprehensive coverage of the economy, extending from firms and employees to households as consumers, and as suppliers of labour and, in some versions, as providers of land and capital.

Based on examination of relevant literature and other information, this review has developed a set of criteria to assess specific methods for estimating sub-national, regional and local economy impacts of transport. These criteria are: consistency with economic theory; impacts and assumptions supported by empirical evidence; consideration of the spatial distribution of impacts, including localities that are disadvantaged as well as those that gain; the use and availability of relevant data; dependency of impacts on other factors; implementability; and the appropriateness of the metrics produced.

The review found that all of the existing methods have strengths and weaknesses, and there is currently no single method which could be consistently applied across all scheme types. For example, some methods focus specifically on the local area and do not take account of displaced impacts which occur outside of the area. Others are dependent on data which is not readily available at the necessary spatial level, while some methods assume causal relationships between transport connectivity and productivity that are not backed up by robust evidence. In addition, some methods are more suitable for the appraisal of small, local schemes while others are more effective when applied to large urban or inter-urban schemes.

It is clear that the methods identified and assessed in this review can be further adapted and developed for estimating the sub-national, regional and local economy impacts of transport. However, some methods are better suited to addressing specific questions than others, and many of the methods have been specifically designed to address a particular need. The choice of the appropriate approach to use, and identification of how the method should be further developed, will therefore depend to a large extent on the specific questions that need to be considered and addressed.

2   Introduction

2.1   Background to Study

2.1.1   In recent years, the Department for Transport has developed guidance on estimating Wider Impacts of transport, which identifies a number of impacts that were considered to be either missing or only partly counted directly in transport user benefits. The Wider Impacts for which detailed guidance is now provided in WebTAG are:

- **Agglomeration impacts** i.e. the productivity benefits that some firms derive from being located in close proximity to other firms;

- **Output change in imperfectly competitive markets** i.e. the welfare gains above the cost of production that result from an increase in output generated by a transport improvement;

- **Labour supply impacts** i.e. the benefits generated by more people deciding to enter the workforce; and

- **Move to more or less productive jobs** i.e. the benefits brought about by allowing members of the labour force to move to areas of employment where they will be more productive.

2.1.2   More recently there has been interest in estimating the impacts of transport on economic growth and economic activity for specific geographical areas. Alternative methods have been developed for estimating how transport investment impacts on economic growth and economic activity. Estimates produced from these methods could be considered alongside the welfare impacts generally estimated in transport appraisals. These approaches have focussed on how transport impacts on economic output and employment by affecting the scale and pattern of economic activity, through, for example, a change in the location and number of jobs and higher levels of productivity.

2.1.3   As there is currently no definitive guidance within WebTAG on this matter (because it is largely focussed on the welfare-based approach and is generally concerned with impacts at a national level), DfT commissioned this review to assess approaches that could be used to estimate sub-national, regional and local economy impacts.

2.2   This Review

2.2.1   This review was required to:

- Identify the types of modelling and appraisal methods that could be used for assessing the sub-national, regional, and local economy impacts of transport proposals.

- Develop a set of criteria that can be applied to assess these methods. These criteria should include consideration of the theoretical and practical robustness, feasibility, practicality, and proportionality, and other criteria that the research identifies to be relevant.

- Assess the identified methods against these criteria, identifying the key strengths and limitations of each type of method.

- Provide detailed options for further research to further develop methods for the modelling and appraisal of impacts of transport schemes on sub-national, regional and local economies.

2.2.2 In the context of this study, the definition of a 'method' might range from a fully validated model to the application of empirical evidence in support of assumptions made about economic impacts.

2.3 Approach

2.3.1 The process for this review has involved a number of stages to build towards the assessment of the approaches and our overall conclusions. This is illustrated in Figure 1 below.
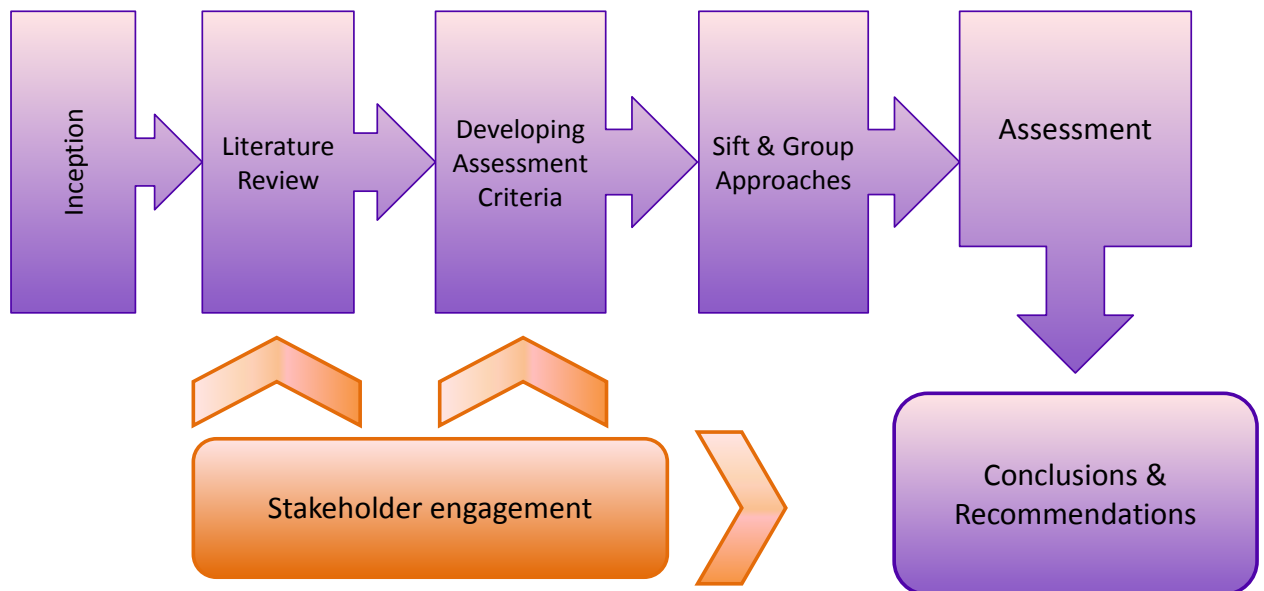

Figure 1 Research Approach

2.3.2 The inception stage and literature review involved collating relevant literature and other material and information. A full list of references and documents considered is provided at the back of this document.

2.3.3 This enabled the study to identify methods which have been, or could be, used to estimate the sub-national economy impacts of transport schemes. These methods were identified from a combination of academic papers, applications for funding received by the Department, papers provided to this review by consultancies, and literature published by public sector organisations.

2.3.4 Several methods were identified that could be used to estimate the sub-national, regional and local economy impacts of transport interventions. The usefulness of the different methods that have been developed generally differs according to the problem to be addressed. For example, one method is intended to provide information about the effects of

schemes designed to unlock development sites, access to which was previously constrained. Another approach is aimed at understanding how improved accessibility to a conurbation might contribute to the productivity of that city region.

2.3.5 The main differences between the methods reviewed are in how the method links improvements in accessibility with increases in economic growth and economic activity.

2.3.6 There are, in our view, four broad groups of methods. The first method is a survey-based approach which estimates changes to the local economy using data on local firms, the role of transport in their business, and how the change in transport provision may impact on business and economic performance. The method tends to use local data whenever available combined with evidence gathered from business surveys and interviews, as well as impacts from the implementation of similar schemes elsewhere.

2.3.7 The second category of methods estimates the changes in land use that follow from the scheme. In Land Use and Transport Interaction (LUTI) models, the effect on zonal accessibility from the transport model is fed into a land-use model with feedback to the transport model to develop a consistent account of the combined effect of an intervention on the transport and land use system.

2.3.8 The third category of models estimates the relationships between transport connectivity and productivity. Some versions of these models also estimate the relationship between connectivity and the level of employment in the urban area, leading to the finding that investment in urban transport may increase both productivity per employee and also may increase the number of employees in the urban area.

2.3.9 The fourth category of models, Spatial Computable General Equilibrium (SCGE) models attempt to provide a comprehensive coverage of the economy, extending from firms and employees to households as consumers, and as suppliers of labour and, in some versions, as providers of land and capital. SCGE models provide, in theory, the most comprehensive approach capturing the behaviour of all actors in the economy.

2.3.10 Combined with a brief early assessment of the methods, the literature review also enabled the study to arrive at a set of criteria against which the methods could be assessed. The criteria and the process for developing these criteria are described in more detail in Chapter 3.

2.3.11 The assessment of the methods is covered in Chapter 4. Chapter 4 provides a short description of each of the approaches, in terms of the theoretical background, and how the approaches have been used. It also includes a summary of how each of the methods performed against the assessment criteria.

2.3.12 These issues are then developed further in Chapter 5 which includes a discussion on the strengths and weaknesses of the methods considered and assessed. Chapter 5 concludes with a summary of the key considerations in estimating sub-national, regional and local economy impacts of transport and offers some recommendations for further work.

2.3.13 It is important to emphasise at this stage that many of the methods currently being used to estimate sub-national impacts of transport projects have been designed and developed for a specific use. The aim is not to assess their suitability for that particular use, but to determine whether they are suitable in their current form for being applied widely to estimating the sub-national, regional or local economy impacts of transport schemes.

3   Development of Criteria

3.1   Introduction

3.1.1   A key task of the study was to develop a set of criteria which could be used to assess the various methods being applied to estimate the impacts to the economy of transport proposals at sub-national, regional and local levels. This chapter summarises the approach that was taken to developing the criteria, and sets out the finalised set of criteria that was developed.

3.2   Literature Review

3.2.1   A vital component of this study was an initial literature review and data-gathering. This involved identifying and reviewing research and academic papers, material provided to this review by developers of specific models, and a small number of bid submissions to DfT showing examples of where methods had been applied. This enabled us to identify methods that have been, or could be, used to estimate impacts at a sub-national, regional, or local, level. The literature review enabled the study to arrive at a list of key criteria against which to assess specific methods[1].

3.2.2   A full reference list is included at the back of this report and where the assessment of an approach has drawn heavily on particularly references, these are noted in Chapter 3.

3.3   Approach to Criteria Development

3.3.1   The assessment of the methods needs to be set in a transparent and logical framework to ensure that all considerations are covered and that methodologies are assessed in a consistent manner.

3.3.2   The literature review and discussions with the client helped to identify potential criteria and sub-criteria by which to assess the methods, based on the key principles that we felt were important to make a full assessment of the suitability of these methods and their strengths and weaknesses.

3.3.3   The criteria Working Paper went through internal review and revision and the final version is included as Appendix A to this report. The following section presents a summary of the criteria and reasons for their inclusion in the assessment framework.

3.4   Assessment Criteria

3.4.1   The following criteria have been used to assess the suitability of the various methods.

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[1] While none of the methods would necessarily have to meet all of the criteria, it was clear that, if a particular method was to be considered suitable, it would need to address limitations identified with that particular approach.

Criterion: Consistency with Robust Economic Theory

3.4.2 It is clear that the approaches currently being used to estimate the sub-national, regional or local impacts of a transport intervention are based on different fundamental economic relationships linking transport investment and impacts on economic growth.

3.4.3 A good method will provide strong grounds, in terms of the robustness of the underlying economic theory and principles that form the framework for the method, to support the case that a transport intervention will lead to an increase in economic growth.

3.4.4 It will, for example, demonstrate how the transport improvement is expected to feed through to higher levels of economic growth and economic activity e.g. reduction in input costs, increases in output and employment etc. These relationships should be adequately explained in the documentation as should any further initiatives necessary to deliver the increase in economic growth.

Criterion: Empirical Evidence

3.4.5 Evidence should be presented to support the impact of the transport improvement on the local economy. A good method will provide empirical evidence to support the claimed impacts of the scheme and also indicate the robustness and uncertainties associated with the evidence.

3.4.6 A particular source of uncertainty can be the direction of causality. Many factors – for example, transport connectivity and employment density – are closely correlated and it is difficult to separate the cause and effect. The method should therefore recognise where this is a difficulty and provide supporting evidence to distinguish between cause and effect in its assumed economic relationships.

Sub- Criteria: Assessment of Land Use and Development Capacity

3.4.7 Conventional transport models generally assume a fixed land use and that transport improvements accrue to existing businesses only by increasing productivity through, for example, reducing travel costs and, in some cases, through benefits from agglomeration. Local economic impact models however can be based on the assumption of flexible land use and business and workforce relocation (for example, to allow a move to more productive jobs and an increase in total employment in the study area). It is important to understand these assumptions and their robustness.

3.4.8 The method should also be clear whether assumptions about changes in land use have implications for the estimates of demand derived from the transport model if this is based on a different land use assumption.

Sub-criterion: Labour Supply

3.4.9 It is important that a method or model used can clearly explain the impact and assumptions on the supply of labour, including how these impacts are expected to occur over time. Presenting a transparent account of the impacts on the labour supply will be crucial to the credibility of the method and results. For example, in estimating employment impacts, what assumptions are made about the supply of labour and how it is expected to contribute to higher levels of economic growth?

3.4.10   The method should be clear whether the results are dependent on a supply of labour resource e.g. unemployed labour, and provide the evidence to demonstrate that this exists in the form assumed e.g. skilled or unskilled or whether increases in the labour force are a result of relocation of workers from outside the study area. The method should also explain whether the supply of labour anticipated to enter the workforce has the necessary skills and qualifications to meet the demand, and if not, how does it obtain these?

3.4.11   The method should also be clear about, if there is claimed additional output per person, what causes the increased output? Evidence should be provided to support this effect and that it is caused by the transport improvement. The method should explain whether the increase in output is from 'real' agglomeration effects as measured through wider impacts guidance i.e. within the existing sectoral mix, or is the increase in output generated by productivity improvements brought about by a change in the sectoral mix with low value jobs shifting out of the study area and higher value ones moving in.

3.4.12   A good method should therefore be clear whether the method assumes relocation of labour and/or businesses under the do-something option and where the labour supply has come from.

Sub-criterion: Elasticities

3.4.13   A number of the approaches, and the results generated, are dependent on estimates of labour supply elasticities and the response of the workforce to changes in wages. A number also include elasticities of productivity with respect to effective density.

3.4.14   It should be made clear therefore whether the elasticities used are evidence-based or whether there are possible limitations e.g. are the elasticities applicable to the occupations and/or geographic area that contribute to the increases in economic growth, and if not what are the implications?

3.4.15   Information should also be provided about the sensitivity of the estimated outcomes to uncertainties around the elasticity values and the extent of these uncertainties.

Criterion: Dependency on other factors

3.4.16   It is important to understand whether the impacts predicted by the models are dependent on other factors occurring and complementing the transport investment. SACTRA concluded that additional, non-transport investment is generally required to deliver economic impacts[2]. In addition, Eddington concluded that, in itself, transport investment may not create additional economic growth, and that this impact is conditional on other factors, such as local market circumstances and labour market conditions[3].

3.4.17   The method should therefore clearly explain whether the impacts on economic growth are dependent on the transport investment alone, or whether the intervention is assumed to act as a catalyst for a number of other structural changes and market conditions in the local economy. This could include assumptions about flexibility of labour market, and about use of land, business capital, housing, and other factors, and whether such assumptions are credibly supported by evidence.

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[2](Standard Advisory Committee on Trunk Road Assessment, 1999)

[3](The Eddington Transport Study, The Case for Action: Sir Rod Eddington's Advice to Government)

3.4.18   Also, it will be important that the non-transport factors that are needed to generate the impacts are made explicit, including their own benefits and costs.   In addition, evidence should be provided to show that the non-transport impacts are likely to materialise.   This could be by specifying any constraints on planning permission that might influence the level and location of development.

3.4.19   The method should take account of the funding requirements of a particular scheme. Where a local contribution to a scheme is conditional on the scheme progressing and being approved, the method should include some means of representing the local opportunity cost of this source of funds.

Criterion: Counterfactual / Do-minimum

3.4.20   Estimation of economic impacts implicitly or explicitly involves comparison with a counterfactual, usually presented as a base case. It is important therefore that use of the method involves providing a clear explanation of the counterfactual so that there is transparency around the assumptions made with regard to the scenario where the proposed scheme is not introduced.

3.4.21   It will also be important to understand whether the base case is comparable with the base case in the cost benefit analysis transport appraisal.

Criteria: Data Use and Availability

3.4.22   Many of the methods and models identified in this review are dependent on specific data requirements. It is therefore important to understand these requirements and also to understand the limitations of the approach if required data is not available.

3.4.23   The extent to which the data used is best suited to the analysis should be made clear, as should potential problems with the data used. There should be explanation of whether there are any significant limitations or weaknesses with the data used.

Criteria: Uses and Limitations of the Method

3.4.24   It is important to understand the limitations associated with the use of a particular method. For example, are there theoretical or empirical limitations with specific applications of the approach, and are the assumptions of the method suitable for use for specific applications?

Criteria: Calibration and Validation

3.4.25   A potential key issue for determining the suitability and robustness of the methods will be the calibration and validation of the models used.

3.4.26   In a transport model context these terms are well understood in terms of the models representing the present day observed situation and their modelled responses to changes in supply and demand.   There are established parameters in WebTAG which are used to examine the level of calibration and validation achieved and the 'acceptability' of the model in terms of behavioural response.

3.4.27   In the case of the methods considered in this review, however, the modelled relationships are generally not well understood. In addition the complexity involved (i.e. the myriad of factors which affect the real economy) means that there is very little scope to 'validate'

models against observed outcomes over time compared to the case with transport models. For example, with a transport model, the forecast traffic flows on a new road can easily be compared against the actual flows following construction, and lessons can be learned for future forecasting exercises. The economic impact of the new road cannot be observed without untangling the effects of many other factors, which in practice is extremely difficult. These models are also built up from a large number of relationships which themselves have been derived via empirical or theoretical evidence.

3.4.28   Instead, this therefore comes back to the strength of the evidence used to support the key relationships being modelled. For example, the derivation of elasticities and the evidence produced to support these values is a key issue.

Criterion: Compatibility with Transport Model and with Transport Appraisal

3.4.29   It is important that assumptions in the method used to estimate the economy impacts are consistent with the main transport modelling and transport appraisal assumptions. A good method should be clear that there are no inconsistencies between the two sets of assumptions. For example, are these the same as have been used in estimating the relationship between transport costs and output (or employment) from which the employment or productivity elasticities have been derived? Are all mode costs combined or analysed separately?

3.4.30   It would be helpful, for DfT's purposes, if it was possible to develop a single method which is capable of producing results for both welfare and output impacts at both a national and sub-national level. The review will consider whether any of the methods identified are capable of this.

Criterion: Metrics

3.4.31   The different methods may present the outputs using different metrics. The metrics used should be appropriate and meaningful in terms of estimating sub-national, regional, or local economy impacts. In many cases the appropriate metrics will be changes in economic output (measured through impacts on Gross Domestic Product or Gross Value Added), and changes in employment, for specific sub-national, regional and local areas.

3.4.32   Criterion: Winners and Losers and Spatial Distribution

3.4.33   This is a key criterion, as many estimates of economic impact focus solely on the immediate area of impact, without differentiating between newly generated economic activity and activity which has been redistributed from outside of the study area. The resulting analysis should be able to show the economic impact at the national level as well as the geographical distribution. This approach will allow an estimation to be made in terms of net growth as well as how the impacts are distributed geographically.

3.4.34   The introduction of new or improved transport links between two areas could result in both areas gaining an increase in economic activity and employment, and at least net improvements if different sectors within each area are affected positively or negatively. Alternatively, one area could gain at the expense of the other. Indeed, it is possible that the area intended to benefit could see a negative impact on economic growth under certain circumstances, such as inefficient industry and labour market being exposed to outside competition. This is an example of the so called "two-way road" effect.

3.4.35   While there is no conclusive evidence on which areas would generally benefit or lose in response to a transport intervention, it is important to assess how the approach takes account of the impacts outside the study area and explain how factors such as economic growth, labour market performance etc are affected outside the study area, if at all. Again the evidence base underlying this will be important.

3.4.36   Implicit in this is the importance that the spatial area being examined is covered by the model, and whether it accounts for impacts beyond the study area in any way.   The approach should make clear how the redistribution of economic growth and of households is estimated and modelled.

3.4.37   In addition, the method should explain how the displacement of the activities that move to the places benefitting from transport investment has been estimated and modelled. The method should also demonstrate to what extent displacement takes place *within* the study area and the impacts of this and whether the regions outside the study area from which economic activity is displaced identified.

3.4.38   Finally, the models tend to deal with economic impacts (costs and benefits) that materialise over different time periods. It is important that the approaches are able to compare impacts of a particular intervention over different timescales, including the discounting which is applied to ensure like-for-like comparisons. A consistent approach is therefore required to ensure impacts associated with a particular scheme and its performance can be compared on a like-for-like basis.

Criterion: Non-economic Impacts

3.4.39   There may be interest in other, non-economic impacts of an intervention. It will therefore be important to know whether the method identifies other impacts such as environment and social impacts, which might also have an impact on the location of households and employment. What account has been taken of the possible indirect effects on economic output, and is robust evidence provided and explained of these impacts?

Criterion: Implementability

3.4.40   Is it straightforward and practical to implement the method? Can it be adapted to be easily implemented to the specific proposal under consideration? Does it require a specific skill base? Can it be used more generally or are there issues such as intellectual property rights or software licensing? What is the preparation time to set up models and their run times? Is there a high risk of error because of complexity?

3.5   Future Development

Transferability

3.5.1   For consistency and to allow like-for-like comparisons across schemes, it would be useful if the method is suited to all scheme types and does not systematically lead to bias when applied to particular uses. It is important to understand whether a particular method can be applied to different transport modes or different types of policy measures, to large or small spatial areas, to urban or rural settings, over time, and for different scenarios. For example, what would be needed to apply a method used in one conurbation to a different location or larger or smaller area, or between different modes of transport?

Future Potential of Each Approach

3.5.2   While a particular method may not necessarily be robust in its current design, it would be useful to understand to what extent it could be further developed. For example, there may be new data or research planned which could increase the robustness of the approach.

3.5.3   A number of the methods currently being have been developed, and are owned, by private sector consultancies. As explained under the 'implementability' section, model ownership, licensing and intellectual property rights are clearly issues in considering potential and future use.

4 Assessment of Methods

4.1 Introduction

4.1.1 This chapter provides a summary of the assessment of the various approaches against the criteria. The assessment of the methods began by firstly reviewing the approach to, for example, understand how it works, what are the underlying principles, what are the economic relationships, how has it been used and what are the required inputs and the resulting outputs? The chapter is split by method and begins by providing a short description of the approach and the underlying theory supporting it.

4.1.2 After the description of the method, each section includes a summary of how the approaches have been considered by this study to perform against the criteria. It should be noted that this chapter focuses on the main conclusions of the assessment. A comprehensive assessment of each method against all criteria is recorded in the tables in Appendix B.

4.1.3 In carrying out the literature review of the methods being used to determine the sub-national, regional and local economy impact of a transport intervention, a number of approaches were identified. In some cases, different approaches were identified based on the similar underlying principles and methods. In those cases the methods were bundled under a single approach. In summary, the approaches can be grouped under the following types:

- Survey-based Approaches;

- Regeneration and Economic Activity and Location Impacts;

- Land-Use Transport Interaction (LUTI) Models;

- Urban Dynamic Model (UDM);

- Wage Equation Models;

- Structural Model;

- Partial Equilibrium Models; and

- Spatial Computable General Equilibrium (SCGE) Model.

4.1.4 The chapter is therefore structured by discussing each of the above methods in turn.

4.2 Survey-based approach with employment density calculations

Summary Description and Theory

4.2.1 The first of the methods reviewed involves the most simplistic approach to measuring economic impacts. The approach, similar to many of the others discussed in this chapter, is based on the theory that changes to transport networks can affect business performance and

economic growth by altering accessibility. By improving transport this can improve accessibility, open up opportunities or 'unlock' potential development. In the case of unlocking potential development, existing transport networks may make the potential development unattractive due to congested networks or poor access to the necessary labour force. This problem may be addressed by improving the transport network.

4.2.2   The survey-based approach uses a combination of local planning data and business surveys to estimate the level and type of business premises that will be created in the new developments e.g. office, light industrial, general industrial, warehouse and distribution, or retail and leisure. Depending on the type and mix of accommodation and the amount of new floorspace released, estimates are then made of the additional jobs that will be created[4].

4.2.3   Business survey data is used to provide evidence of the impact of the with and without scheme in terms of: supply and demand for particular types of premises by company size; current and future needs in terms of access to customers and suppliers; current and future needs in terms of access to and demand for labour; strengths and weaknesses of current location; movement of goods and services etc.

4.2.4   Providing survey evidence of how a transport investment will unlock potential development, estimates of employment are then made, for example, using the Homes and Communities Agency's (HCA) guidance on employment densities[5]. The densities are used to estimate the number of jobs that will be created by a certain type of development.

4.2.5   Employment density refers to the average floorspace (in m^2) per Full Time Equivalent (FTE) worker employed. Average employment densities in the HCA guidance have been derived from surveys of a large number of buildings. For example, the HCA guidance indicates that in food superstores $17m^2$ of floorspace generates on average of one FTE. In a business park office $10m^2$ per one FTE. In general warehouse and distribution, $70m^2$ per one FTE.

4.2.6   Adjustments are made for Gross and Net floorspace figures and, depending on the type of use, for full time and part time employment.

4.2.7   Once total FTEs are calculated, adjustments are then made to estimate the number of indirect or induced employment. One approach (which used figures from the Government Office for the South East Objective 2 Programme) assumes a total of three indirect and induced jobs are created for every 10 new FTEs.

4.2.8   Some approaches which have been reviewed have also included analysis to show how, by increasing employment density and accessibility, the transport improvement will deliver efficiencies by enabling a better match between the skills of the labour pool and the business requirements of employers.

4.2.9   In terms of metrics, the approach primarily focuses on changes in employment, although these tend to be limited to local (gross) impacts as opposed to national or regional (net) impacts. Some attempts are also made to estimate how an intervention may impact on output (generally measured through local GVA), but examples of this are few.

Performance against Assessment Criteria

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[4] (Bexhill to Hastings Link Road Regeneration Report, 2009)

[5] (Employment Densities Guidance (2nd ed) , 2010)

4.2.10   The performance against the assessment criteria was fairly mixed. On the negative side, key issues are that the evidence used to support the claimed impacts can be relatively weak. In addition, little evidence is provided to demonstrate that the supply of labour is actually available. Where will it come from and do the individuals have the relevant qualifications and experience to match the needs of employers?

4.2.11   Applying this relatively simplistic type of approach can be subject to an element of bias. For example, it is very much dependent on the transport improvement 'unlocking' land for economic development. This is usually based on evidence from local business surveys which, as with other types of surveys, can be prone to elements of bias depending on how the survey is developed and implemented.

4.2.12   The strength of this approach depends on the quality of the evidence that the 'unlocking' of the land is dependent on the transport improvement under consideration and that the development will not take place without the intervention. Alternatively, it is possible that the development could happen elsewhere in the local area. WebTAG unit 3.16D, which sets out the steps to be taken in the cost benefit appraisal to inform the economic case in the case of land for housing development which might be unlocked by a transport scheme, would seem to provide a possible template for establishing the evidence required.

4.2.13   It is not clear how robust the employment density figures and multipliers for induced and indirect employment, are. There does not appear to have been primary research carried out, although estimates can be based on survey evidence of previous cases.

4.2.14   In the cases reviewed, there is little consideration of the impact on activity outside of the local area. However, this may reflect the purpose of the analysis. This type of analysis has usually been applied to understand the local impact for a particular local authority which may have limited interest in impacts outside its boundary. It is unclear therefore whether the national change in employment is likely to be positive, negative or neutral.

4.2.15   The survey-based approach has mainly been used to examine the direct impacts of relatively small transport schemes at an intra-region level. Its application may be more difficult in attempting to understand national impacts if the intervention affects different regions across a larger spatial scale. For example, by only considering the immediate and direct impacts at the local level, the approach would fail to pick up what SACTRA explained as the 'two-way-road' effect and the exposure of local firms to competition from outside the area. The analysis would therefore need to be extended to cover the impacts on individual regions. However, many of the schemes considered are focussed on unlocking development opportunities, as opposed to improving linkages, between locations. While the analysis would still need to cover issues around displaced activity, the two-way road effect and exposure to competition may be less of an issue in a number of cases.

4.2.16   The basis for adding to the estimates of jobs directly attributable to the unlocking of development sites, i.e. an allowance for induced employment in the locality, in many cases lacks any clear evidence base. Further evidence for the extent and spatial distribution of this effect would be desirable.

4.2.17   Given the simplistic approach to calculating the impacts, sensitivity tests would not be difficult and the application of the methods would benefit from tests being carried out to show the impacts of changes to some of the key assumptions.

4.2.18 On the positive side, considering the simple survey-based approach, it is generally clear from the resulting analysis how a transport intervention is expected to feed through to changes in economic growth by removing transport problems that are constraining performance and output. If used correctly, it is also clear what is anticipated under a do-nothing option with the counterfactual explained. Examples setting out the use of the approach have also been clear about the limitations and the type of scheme that the method is best suited i.e. small, local schemes with impacts likely to be concentrated in a relatively small geographical area.

4.2.19 While the approach is not suitable for major transport projects which have impacts across a large geographic area, the method could be applied to support analysis of the economic impacts of 'small' schemes. The approach of applying employment density figures could be calibrated from empirical evidence on employment estimates (both direct and induced) from previous development sites. This could be developed centrally by DfT to allow a more robust evidence base and consistency in approach.

4.2.20 Overall, while the method is relatively simple, it involves less of a 'black box' and could be developed to support analysis of the local employment impacts of small schemes on a consistent basis. While the approach has clear limitations with estimating the impacts of large schemes it could provide the basis of a method suitable for small schemes.

Known Uses

4.2.21 As explained above, this type of approach has been used by local authorities for relatively small schemes and provides an evidence base of how a particular transport intervention can 'unlock' development and generate employment at a local level. This review has not found examples of this particular approach being used to inform the impact of larger schemes.

4.3 Regeneration Impacts and Economic Activity and Location Impacts (EALIs)

Summary Description and Theory

4.3.1 The Department for Transport provides guidance in WebTAG[6] for estimating the impacts of a transport scheme on the local economy of a regeneration area. This guidance provides a framework for estimating employment that may be created in a regeneration area (RA) due to improved travel conditions a scheme delivers or by giving residents access to jobs that were previously inaccessible. The estimated impacts are then recorded in a 'Regeneration Report' (RR).

4.3.2 The RR approach begins by conducting an audit of the existing position within the RA, including considering the constraints and market weaknesses. More specifically, analysis should be carried out to explore the precise role that transport plays in the local economy and how the proposed scheme is likely to remove constraints and weaknesses and affect employment levels.

4.3.3 In addition, an analysis of existing businesses, sectors and key employers should be carried out, to build up a picture of the local economy, in terms of: its current and recent performance; the factors leading to its present position, future expectations; and constraints on expansion.

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[6]WebTAG Unit 3.5.8, Department for Transport, April 2011

4.3.4   It is explained that much of the information required will be available from current data sources including data produced by Office for National Statistics, Local Authorities, and central government departments. Information may also be available from the Local Economic Partnerships forthcoming Strategic Economic Plans.

4.3.5   Using the information gathered, the estimation of regeneration impacts involves developing the case for the impact of the proposed transport scheme on economic activity e.g. how it will affect patterns of accessibility. It is explained that a central task in preparing a RR will be to demonstrate how patterns of accessibility will be changed, and then to show how these changes will affect patterns of economic activity, leading to reductions in unemployment. The analysis will include, for example, changes in:

- Access to a suitable workforce;

- Access to customers and suppliers; and

- Access to suitable employment.

4.3.6   Taking on board the results from the analysis (including factors such as the potential to attract inward investment, shortage or otherwise of business premises, shortage and availability of housing, potential to attract tourism through new and repeat visits, type of visitor and risk and uncertainty about the situation and impacts etc) will allow an estimate to be made of the number of net new jobs created in the regeneration area.

4.3.7   It is also explained that the analysis should take account of the 'two-way road' effect, by analysing how businesses in the RA may be affected by opening up competition from firms in other locations, with the analysis informed through interviews and survey evidence.

4.3.8   The focus is on changes in employment, specifically the change in jobs in the RA and RA residents in employment.

4.3.9   The Scottish Government's transport agency Transport Scotland provides very similar guidance to that in WebTAG Unit 3.5.8. This is set out in its appraisal guidance document Scottish Transport Appraisal Guidance (STAG)[7]. The EALI[8] analysis is intended to provide an estimate of the impact of a transport investment on the economy measured through changes in output (GDP or GVA) or employment. In theoretical terms the transport intervention, in terms of cost changes, affects different activities in different ways in places served by the scheme and the framework is designed to be applied to estimate the various impacts. Beyond the simple theory, local and specific data is required to populate the framework.

4.3.10   Economic Activity and Location Impact analysis is only required if the distribution of impacts has been identified as important or significant within the early part of Transport Scotland's two-stage appraisal process, and under certain conditions related to scheme cost and location. The guidance indicates that that any decision to omit an EALI analysis must be clearly explained in any final appraisal documentation. .

4.3.11   The approach set out by Transport Scotland has many similarities to the analysis set out in the guidance on regeneration impacts that is provided by DfT. In summary EALIs are reported in two ways. These are:

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[7](Scottish Transport Appraisal Guidance, 2008)http://www.transportscotland.gov.uk/stag/home

[8]http://www.transportscotland.gov.uk/stag/td/Part2/Economy/9.4

- As a net impact at the Scottish level; and

- In terms of its gross components, which will distinguish impacts on particular areas.

4.3.12 An EALI analysis is unlikely to be required for small schemes, except in those occasions where economic impacts are the main or only justification for the intervention or if an early scoping exercise suggests that a particular area is likely to experience significant positive or negative impacts.

4.3.13 In addition, it is also explained that where the main objectives of an option are solely or substantially concerned with economic development or regeneration, the reasons for preferring a transport option rather than other economic development measures needs to be clearly articulated, as well as details demonstrating how the preferred transport improvement will act as a catalyst for the economic impacts.

4.3.14 The guidance also explains that if a transport scheme is seen as a trigger for other wider supporting measures of a particular strategy which will generate the economic impacts, then the secondary impacts need to be explained. In particular, a credible chain of cause and effect must be presented, supported by empirical evidence wherever possible, linking the transport option to its predicted outcomes, namely changes in economic output and / or employment.

4.3.15 In identifying and quantifying the impacts, while a general method is outlined, it is recommended that a case by case approach is adopted and specifically tailored to the intervention being considered and to the appropriate area and spatial level. This then forms a partial analysis, which involves a detailed segmentation of the economic actors in the spatial areas relevant to the appraisal of the particular scheme.

4.3.16 The case specific approach involves analysis of the potential behavioural responses of different sectors of the economy. This is similar to DfT's regeneration guidance. In the context of the EALI guidance, the term 'sector' relates to particular industry areas of economic activity, such as manufacturing or financial services. Within each sector there are 'economic actors' whose decisions impact on the economic growth of a location. Economic actors include firms both in and outside an area, land and property developers, and individuals in their roles as residents, workers, shoppers, visitors etc.

4.3.17 Once useful segmentation has been selected for the area concerned, the approach involves examining how the various economic actors within each relevant sector might be affected by, and respond to, the changes in, for example, cost or accessibility brought about by the transport scheme being considered.

4.3.18 It is explained that in most instances, much of the required analysis will be based on survey evidence and accessibility analysis. For example, a combination of data gathering and structured interviews could be used to establish, for business sectors:

- Current performance, including size, recent growth, profitability / margins;

- Future objectives and aspirations – product size, markets, production locations;

- Current and future constraints, to include physical resources, human resources, management and capital;

- Output / product market conditions / competitiveness;

- Location and size of main competitors;

- The significance of transport and accessibility to the business; and

- The role of changes in transport costs and journey time reliability in overcoming constraints and achieving future objectives and aspirations.

4.3.19   To enable a systematic approach to the identification and quantification of impacts of a scheme, it is explained that each case should be segmented to identify the principal sectors which act as the sources or drivers of economic growth at the appropriate spatial level. Then for each sector, the potential role of the option in enhancing its economic performance needs to be considered. In most cases, this will require a reasonable understanding of the potential responses of the economic actors within each sector to the transport option.

4.3.20   The information gathered and analysed is brought together in Summary Assessment Tables. The aim is to populate the table using a combination of qualitative and quantitative material built up from that gathered for individual sectors. It is explained that this two-stage approach is recommended because the review of the qualitative aspects is then used in identifying which impacts are likely to be most important (in gross terms) and therefore provide a guide to focus efforts on estimating the quantitative impacts. An example of a Summary Assessment Table is included below for illustrative purposes. It is taken from STAG for a particular example, but shows the type of information which would be required, depending on the nature of the scheme under consideration. Further guidance on preparation of this table, and the data collection required, is provided in the guidance on the EALI approach that is published in STAG. Note that the table shows, on the left hand side, the effects on the region or area which is directly affected by the scheme and the right hand side shows the net impacts at the national level i.e. Scotland as a whole.

Table 1 Example of EALI Summary Assessment Table

Year of Assessment	Summary of Impacts			
(year): XXXX	**Local**		**National**	
Sector	**Gains / Gainers**	**Losses / Losers**	**Gains / Gainers**	**Losses / Losers**
Manufacturing and Processing	1200-1300 jobs £70–90m in GDP	None	as local	Very limited – loss estimated up to 100 jobs
Locally Traded Services	Zero	Zero	Zero	Zero
Externally Traded Services	Zero	Zero	Zero	Zero
Inward/Mobile Investment	500–1000 jobs £40–80m GDP	Zero	Zero	Zero
Tourism	Zero	Zero	Zero	Zero
Day Trips/Shoppers	Zero	Zero	Zero	Zero

Residents	500–1000 additional residents	Zero	Zero	Zero
Sector Interactions/ Synergies	200–500 jobs £15–40m	Zero	100–200 jobs £10–20m GDP	Zero
Total Gross Impacts	1900–2800 jobs £125–210m GDP	Zero	1300–1500 jobs £80–110m GDP	loss of 100 jobs, up to £10m GDP
Net Impact	*Overall Impacts Local:* 1900–2800 jobs; £125–210m GDP *National:* 1200–1400 jobs; £70–100m GDP		*Summary of Distributional Impacts* *Local:* potential for benefits in regeneration areas affected by the option, and also at peripheries of TTWA *National:* minimal losses in competitor companies, likely to be short term as external markets expanding	

4.3.21   To support the analysis on distributional impacts on economic activity and employment, more detailed guidance is also provided[9] on topics such as:

- Links between transport improvements and inward investment;

- How transport investment can attract population and feed through to changes in economic growth;

- Place and People Impacts;

- Selection of the appropriate spatial area to be considered;

- The use of, and evidence supporting, multiplier impacts;

- Full and temporal additionality; and

- The use of gross and net impacts.

4.3.22   In terms of outputs, the key metrics that the framework focuses on are changes in employment (gross and net) and changes in output (measured in GDP or GVA).

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[9]http://www.transportscotland.gov.uk/stag/td/Part2/Economy/9.4.5

Performance against Assessment Criteria

4.3.23   While the DfT's Regeneration Impacts and Transport Scotland's Economic Activity and Location Impacts approaches do not necessarily involve applying a unique method, they provide a useful framework for estimation of sub-national economy impacts of transport interventions.

4.3.24   The framework, set out in DfT's Regeneration Impacts guidance, and Transport Scotland's EALI guidance performed well against the assessment criteria. Many of the issues are similar to the more simplistic survey-based approach using employment densities. This is because the underlying approaches are similar, although both the DfT and Transport Scotland approaches involve a more detailed and structured approach to evidence gathering. However, there are issues around survey bias and robustness of the evidence of the transport intervention supporting higher employment or increased levels of output.

4.3.25   The EALI framework, if followed correctly, results in an analysis that should include an explanation of whether impacts are dependent on other factors complementing the transport investment and that takes account of other geographical winners and losers outside the area of consideration. It is important to note that the DfT guidance on regeneration impacts does not require analysis of the impacts on employment in those areas outside of the regeneration area under consideration. This is because the focus of the analysis is on how the transport scheme can support an area in need of regeneration, with the acceptance that the benefit may involve displacement of employment from other areas that are not designated for regeneration.

4.3.26   By encouraging consideration of the winners and losers it is then possible to estimate the national as well as the sub-national / local impact. The EALI framework can therefore result in useful information on national and local impacts.

4.3.27   On the negative side, for large schemes it can involve a significant resource to collect the data required to inform the analysis. This is particularly so for survey data required across different spatial areas, different sectors, and a range of company sizes. Some of the required information is readily available from official sources, but this would need to be accompanied by data collected through specifically implemented business surveys for the transport scheme under consideration.

4.3.28   Particular issues with the Regeneration Impacts analysis are that it does not account for impacts outside of the area under consideration and the metrics specifically focus on changes in employment rather than output. However, these are areas that could be addressed in development of the method.

4.3.29   Overall, these approaches provide a more structured framework than the simple survey-based approach, and they could be further developed to address specific requirements on estimating sub-national, regional and local economy impacts of transport.

Known Uses

4.3.30   The regeneration impacts approach has been used in several schemes, and these have tended to be local transport schemes with strong local and regional regeneration objectives.

4.3.31   The EALI approach has been used in a large number of transport projects in Scotland. In terms of Central Government funded schemes, these have tended to be large infrastructure

schemes with a national impact, such as the new Forth Crossing and major road improvements, such as the M8 Northern Extension in Glasgow. It has also been used to support the case for large regional projects being promoted by authorities but requiring funding from central government. Examples of this include the Airdrie-Bathgate rail line, re-introduction of the Edinburgh-Scottish Borders Rail line, and the Edinburgh Tram. These projects have all had a strong economic growth objective as part of the rationale for the investment and the analysis has been used to provide the empirical evidence to support, or otherwise, the claims made about the economic impact of the scheme. In many of these cases the analysis has been supported by the Transport Economic and Land Use Model of Scotland (TELMoS) in addition to involving significant data collection and surveys.
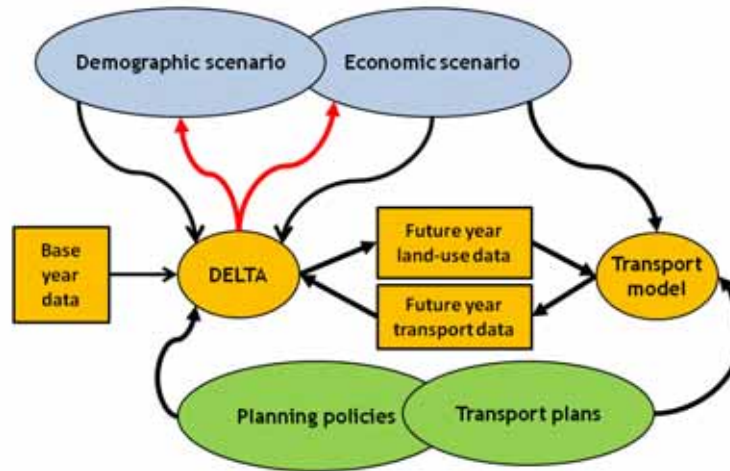
4.3.32   The approach has also been used to examine the potential economic impact of relatively small transport schemes. However, the schemes considered have all had strong economic growth and regeneration objectives and the analysis has been used, therefore, to explore the likelihood of the potential economic impacts materialising and their magnitude.

4.4   LUTI Model assessment

Summary Description and Theory

4.4.1   Land Use Transport Interaction (LUTI) models seek to represent the key drivers behind the changes in land use, economics and demographics within a modelled area, which can vary from a town or city to a national level. They were developed initially to model urban areas from the perspective of the location of land uses, together with the key linkages which drive change within the urban environment.

4.4.2   A LUTI model is essentially a spatially disaggregated model incorporating up to hundreds of individual zones.   Within the model, land uses (including population and employment location) respond to changes in transport conditions and transport (including the main passenger flows between the different zones) responds to changes in land use conditions. Both land-uses and transport are influenced by economic and demographic scenarios, which may be fixed or may respond to the modelled conditions. Land uses respond to planning policy inputs, and transport to schemes or transport policy inputs, which can be specified individually or in combinations at the most detailed level of the model.

4.4.3   The individual components of the LUTI model (with the land use element represented by the 'DELTA' model) are summarised and presented in the following figure.

Figure 2 Scenarios, Policies and LUTI Modelling (from David Simmonds Consultancy)

4.4.4   For the assessment of this type of approach we have focussed on the DELTA[10] software (considered here as the most widely used in the UK). While other LUTI models were considered, we have not found any examples of how they have specifically been used to estimate the sub-national economy impacts of a transport intervention.

4.4.5   In summary, the DELTA software package has continued to be developed over almost 20 years. It was initially designed to be used in conjunction with a range of transport models to create LUTI models. The package now provides the platform for a variety of models, with common features but many differences.

4.4.6   DELTA was designed from the outset to model different processes of change, over different timescales, reflecting the choices made by different categories of actors and the way in which these actors interact through different kinds of markets. The main interactions are shown in the "actors and markets" figure below.

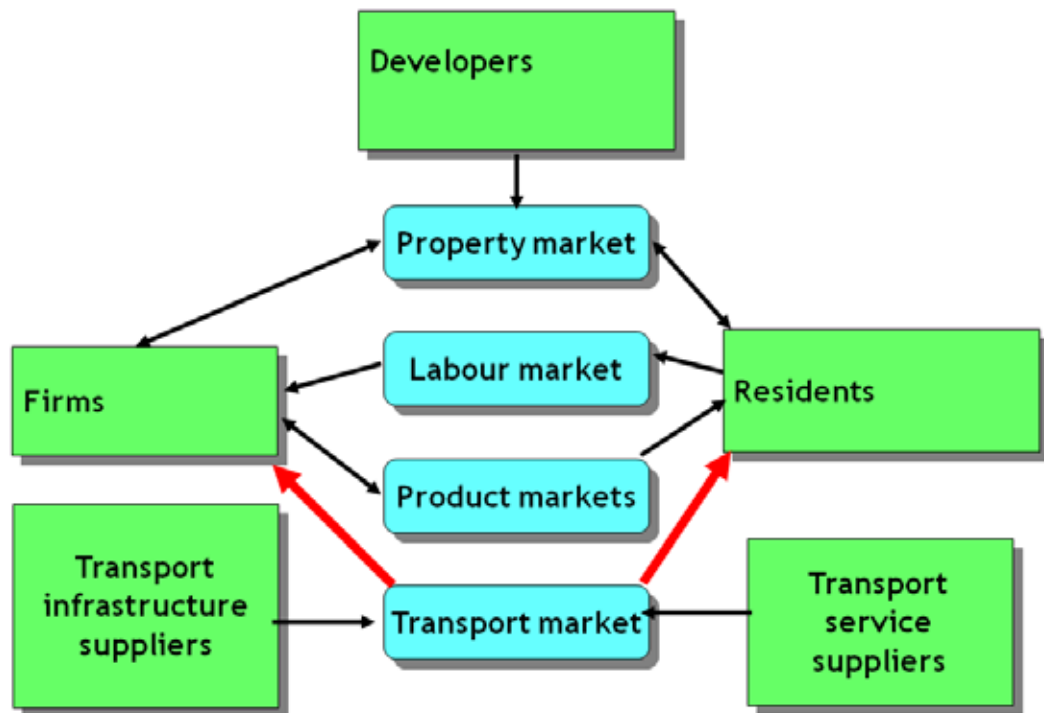[10](Simmonds, 2013)http://www.davidsimmonds.com/index.php?section=34

Figure 3 Actors and Markets in the Urban/Regional System (from David Simmonds Consultancy)

4.4.7 The DELTA model generally has two tiers i.e. urban and regional and these seek to represent different demographic and economic behavioural responses. Urban models represent self-contained areas, such as towns or cities, whereas regional models, which build on the urban models, allow the modelling of employment and economic impacts across a wider regional, sub-national or indeed national area. For example, a regional model could be used to estimate the distribution of economic activity across these wider areas as a result of a transport scheme in terms of e.g. changes in total employment or GVA. This two-tier urban and regional approach of the modelling allows a separate consideration of intra-regional and inter-regional choices within the model.

4.4.8 Some LUTI models are implemented on a zero-sum basis: employment and/or GVA are constrained to a modelled area total and the impacts of any transport scheme modelled in a LUTI context will always be distributional. (In these cases the modelled area is often much larger than the area of policy interest, meaning that redistribution can occur over a very large region or whole country.) Other LUTI models allow the total scenario for a region or sub-region to vary, usually by 'pivoting' around a core forecast (which can be implemented to follow NTEM or equivalent).

4.4.9 LUTI model outputs (essentially, population, employment and GVA, which can be provided at a fairly disaggregated zonal level) can be developed to be used to estimate a number of Wider Impacts i.e. (i) agglomeration economies; (ii) benefits from improved labour supply; and (iii) moves to more productive jobs. These outputs can be determined at a study-wide as well as area level. These calculations are external to the model, using model outputs; they can be calculated including or excluding the effects of land-use responses to the scheme

being appraised. We understand that work is being undertaken[11] to explore the possibility of bringing some of these mechanisms within the model structure in future, as each of these has the potential to impact on the spatial distribution of population and employment.

4.4.10 The higher level representation of economic changes is represented within the Regional Economic Model (REM) component of a LUTI model. This REM comprises a cross-sectional spatial input-output model and an incremental model of investment or disinvestment in each sector and in each sub region.

4.4.11 A clear example of the key logic chain of the impact of a typical transport project has been provided as follows:

- The improvement in transport improves the accessibility of locations to their markets and suppliers;

- A higher proportion of investment is attracted to these areas; and

- The higher rates of investment lead to higher production volumes, which require more labour and employment in these areas is increased.

4.4.12 LUTI models are complex and, similar to transport models, require specialist expertise to develop. Similarly to large transport models, the resource costs involved for development of a LUTI model can be high and it is a significant and long-term commitment on the part of a public body to make. Any third party would have to pay a licence fee for the software and significant training would be required to operate and develop any model in situ.

4.4.13 However, LUTI models can provide valuable insights into some of the key questions relating to the economic impacts of transport proposals – particularly at the regional and sub-regional level. The models also provide the means to estimate Wider Impacts in line with existing DfT guidance. The current models are less helpful in a national context as the impacts modelled are distributional in nature at that level. The developers do state however that there are plans to address this issue in future though.

Performance against Assessment Criteria

4.4.14 In summary, the DELTA package, as the main example of the LUTI modelling approach in the UK, is a powerful tool and has been a useful application for meeting the specific purposes for which it has been designed and developed. There is a clear explanation of the economic theory and principles that form the framework of the method. In addition, it provides a clear and coherent explanation of how a transport intervention is assumed to affect the labour supply and how this contributes to higher levels of economic growth. It also provides a clear explanation of the counterfactual. The data required for the application of the method tends to be available. It also reports the impacts on winners and losers. There is clear guidance on its use and limitations of the approach that users should be aware of. While the approach provides the impacts on key metrics such as GVA and employment, it can also produce impacts in terms of non-economic impacts, such as social and environmental indicators. Another positive is that LUTI models do typically take explicit account of planning policy, such as land use allocations.

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[11] Modelling the Economic Impacts of Transport Changes: Experience and Issues, David Simmonds and Olga Feldman

4.4.15   On the negative side, there is not necessarily a clear explanation of the empirical evidence supporting the claimed impacts. For example, are the impacts dependent on other factors occurring to support the transport investment and if so what are these. However, as noted above, it should be noted that LUTI models do typically take explicit account of planning policy, such as land use allocations. It is also not clear what evidence there is to support the elasticities used in the analysis.

4.4.16   The opportunity to apply LUTI models more widely for use in measuring sub-national economic impacts could be problematic. The documentation produced to accompany LUTI models can be highly technical in nature. In addition, the modelling of the relationships between transport cost changes and land use, demographics and economics are highly complex. The main constraint to the wider use of LUTI approaches is the level of resources required to create, operate and maintain such a model.

4.4.17   Related to the above, the models can be 'black box' in nature. There is considerable specification and detailed intervention involved which adds to the 'black box' characteristic. While this is not necessarily uncommon in the transport modelling field it could be a problem for wider application to relatively small schemes.

4.4.18   Data for the economic variables used to convert the LUTI Model's estimates of spatial impacts into changes in GVA are derived from a number of sources. Some of the required data can be taken from the DfT Economic Dataset that is published alongside the Wider Impacts guidance in WebTAG, and alternative data sources are identified when used in application of LUTI modelling.

4.4.19   Developments to the approach to enable increases in labour supply would be desirable so that it can reflect the evidence on the labour supply elasticity that is documented in the WebTAG guidance on Wider Impacts.

4.4.20   The models can require significant amounts of data, particularly with regard to economic and demographic data requirements.

4.4.21   Nevertheless, the information that can be provided from use of a LUTI model can be of value and there may be a case for investing in a LUTI model in the case of major projects. The incremental cost of deriving estimates of the sub-national economy impacts from a LUTI model used to estimate likely land use changes are expected to be low once the development work described above is completed.

4.4.22   A key strength of the LUTI approach is that 'winners' and 'losers' are clearly identified within the model area. For larger models this data can be presented at e.g. local authority level. This information and supporting evidence generated from application of LUTI models has been used to make the case for transport schemes which provide benefits to areas in need of development and regeneration at the expense of relatively more prosperous areas.

Known Uses

4.4.23   The DELTA package has been used to inform a large number of transport studies. These include the use of urban models, sub-regional models and regional models. Examples include:

- Urban models for Edinburgh and Greater Manchester;

- Sub-regional models for South Essex, Leicester and Leicestershire and South Hampshire; and

- Regional models for Trans-Pennine Corridor, Glasgow & Clyde Valley, Transport Economic Land-use Model for Scotland (TELMoS) and LonLUTI.

4.5 Urban Dynamic Model

Summary Description and Theory

4.5.1   Another method applied to estimate the sub-national economy impacts of a transport scheme involves the use of the Urban Dynamic Model (UDM)[12].

4.5.2   The UDM is a simulation of how an urban area, or a region, evolves over time. It uses feedback loops and time delay. The methodology has been developed to simulate the interactions between transport and the wider social and economic activities of an urban area, with a particular emphasis on transport's impact on jobs and employment, focusing on interactions between:

- Transport;

- Land-use;

- Employers; and

- Population.

4.5.3   It uses an explicit theory of cause and effect, aiming to simulate how people and employers respond to the changes in the world around them. It is built using specialised simulation modelling software (Vensim) and methodology (System Dynamics) using building blocks of stocks and flows.

4.5.4   The UDM divides a spatial area into a number of zones all linked by one or more transport network(s). Levels of activity in each zone are affected by the attractiveness[13] of each zone either as a place to live or a place to work.

4.5.5   The attractiveness of a place for households to live in is assumed to be a function of two factors: the availability of suitable housing and employment.

4.5.6   For employers, the attractiveness of a place is a function of the availability of suitable premises, the ability to recruit a suitable workforce, and access to customers and suppliers.

4.5.7   The model assumes that households are constantly in a state of churn, with households moving in and out of each zone as the attractiveness changes. The net inward flow increases as a zone becomes more attractive and decreases as it becomes less attractive. The rates at which the inward and outward migration takes place are essentially driven by the level of attractiveness of, or utility derived from living in a particular zone. If a zone becomes more attractive, say through the development and availability of more housing, it

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[12](Transport and the Urban Environment: The Urban Dynamic Model, 2008)

[13]The term 'attractiveness' is used as a proxy for 'utility'.

will encourage more people to move in, while the rate of outward migration from the area under consideration will slow. If it becomes less attractive, say through a worsening of labour market conditions, inward migration will decline and outward migration will rise. These responses are all lagged to reflect the time it takes for people to respond to circumstances.

4.5.8   Similarly for businesses, the model owners explain that the rates at which new business will locate in or leave a particular zone will be determined by the ability to recruit, the availability of premises, and access to customers and suppliers.

4.5.9   Households require houses to live in and businesses need premises to occupy, so the model also includes representations of builders and developers who provide the necessary infrastructure. Similarly to businesses and households, premises and houses are being built or demolished continuously and the rate at which this happens is dependent on the attractiveness of the zone to developers. The attractiveness for developers will be influenced, therefore, by: adequate land to build on; rising demand, so that good returns can be had from the investment; and a favourable balance of supply and demand for premises.

4.5.10   Each zone in the model is therefore stocked with information about housing, households, land (essentially the availability of land with planning consent) and land prices, businesses, business premises etc, all of which, it is explained, can vary over simulated time as the attractiveness measures for each component vary.

4.5.11   The documentation provided explains that transport systems enable access between and within the zones and therefore impact on the attractiveness of the zones in three ways[14]:

- A reduction in transport costs and times will tend to increase the range of employment opportunities available to resident workforce, making it easier to get them into employment and therefore increasing the attractiveness as a place to live;

- A reduction in transport costs increases the accessible workforce for employers to recruit from, enabling expansion of employment activity; and

- A reduction in transport costs can impact on businesses' access to customers and suppliers. The model assumes that as the pool of accessible businesses increases, this increases a location's attractiveness and in turn attracts more businesses.

4.5.12   If something happens to stimulate growth in population or jobs, the growth will not continue indefinitely, because at some point a new constraint will start to bite. For example, the rate of growth in jobs will fall if recruitment starts to become difficult, or if no more premises are available; growth in population will slow if insufficient houses are available or if there are insufficient jobs for newcomers. It is explained that, ultimately, land is the limiting factor.

4.5.13   The most recent version of the UDM can represent five transport modes: highways, heavy rail, light rail, bus, walk and cycle. The model uses traditional logit and hierarchical logit models to handle mode and route choice in a way which most transport modellers would recognise. The main difference is that they are used in a dynamic framework in which explicit recognition is made of the time needed for individuals to adapt their behaviour.

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[14] These relationships also work in reverse i.e. following an increase in transport costs can make a place less attractive

4.5.14   Published statistics can be used to assemble much of the data required to populate the model zones for a base year.

4.5.15   Various ways of supplying the necessary transport information have been developed. If a transport model already exists then it is possible to convert its network structures to a form that the UDM can employ. It is explained by the model developers that this has been done, for example, with SATURN and TRIPS networks. It is also explained however that in many cases some simplification of the networks is needed because these models will tend to work with smaller zones than used in the UDM. There are also publicly available highways models that, in some cases, can be used to provide highways information.

4.5.16   The largest applications to date have had up to 200 zones, with around 1500 highways links explicitly modelled, six classes of business and between two and four classes of people, houses, business premises and work skill groups.

4.5.17   The figure below gives an illustrative 'summary' of how the model is structured using the Systems Dynamic paradigm. The lines are causal links connecting each element of the model, with +/- signs used to indicate where changes move in the same direction or opposite. For example, an increase in transport costs would tend to reduce the accessible workforce available to an employer (the negative sign indicates changes move in the opposite direction), which in turn will tend to reduce the attractiveness of a zone for business activity (the plus sign means accessible workforce and attractiveness tend to move together in the same direction). The cause and effect sequence can be traced though complete circles in many cases; these are examples of feedback.
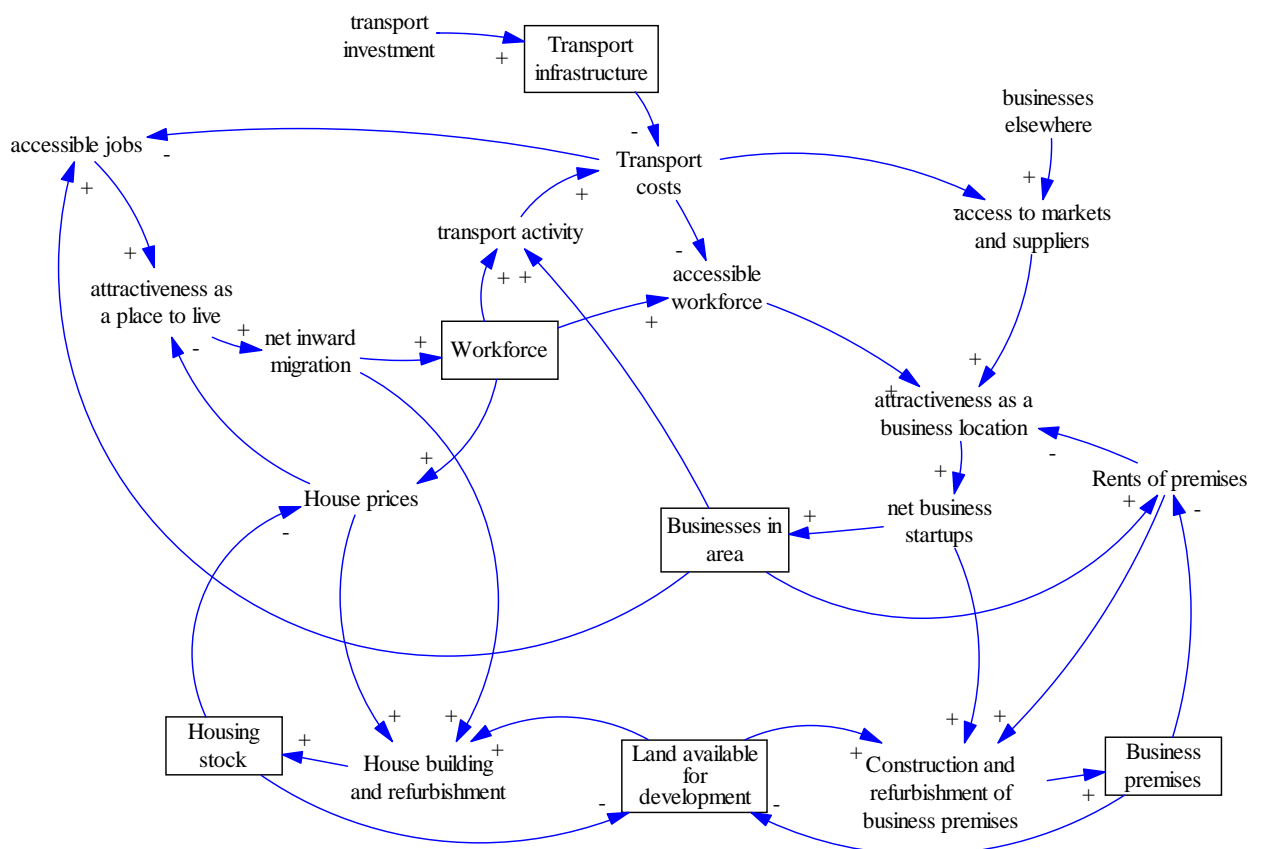

Figure 4 Illustrative Summary of Urban Dynamic Model

4.5.18   The UDM has been developed and applied in a number of cases by its model owners. Its uses include an estimation of how transport investment can contribute to regeneration and economic growth. Impacts can be measured through changes in the following metrics:

- Households and workforce;

- Jobs;

- GVA;

- Residents employed;

- Travel to work matrices, by mode;

- Accessible jobs;

- Vehicle kms and passenger kms;

- CO_2 emissions; and

- User benefits.

Performance against Assessment Criteria

4.5.19   Overall the Urban Dynamic Model performed well against the assessment criteria. The model simulates how individuals, businesses and developers behave in response to changes in attractiveness in conditions. The modelled responses by the various actors are based on empirical survey-based evidence. The model is calibrated against observed data for the particular target area (time series and cross sectional). For example, surveys of businesses have consistently shown that they make their location decisions based on the availability of suitable premises and qualified labour as well as good access to customers and suppliers. Many of the parameters used in the business and employer model were estimated as part of a study that was completed (for other purposes) for DfT[15].

4.5.20   Other positives include the ability of the model to work under the assumptions of either fixed or flexible land use conditions, and it also explains how the transport intervention is assumed to affect the labour supply in the study area and how this feeds through to higher economic growth. The model also generates metrics that would be useful, in terms of impacts on GVA and employment.

4.5.21   The model does not explicitly use elasticities. However each application is subjected to tests that generate changes in behaviour. The changes in behaviour are regularly compared to published evidence / parameters to ensure the model is predicting plausible behavioural responses that are consistent with observed data.

4.5.22   The model also provides impacts on other areas to allow estimation of the net as well as gross results across the various metrics. It can therefore be used to measure the impacts of transport schemes across a range of impacts as well as the distribution of these impacts.

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[15] The Impact of Transport on Business Location Decisions, 2007

4.5.23   While there is no discounting applied in the simulation, the metrics are generated annually over a number of years and the impacts could therefore be discounted. This would allow a comparison of the present value of different interventions.

4.5.24   A possible weakness is that the UDM is a wide area strategic model with relatively large zone sizes and has been primarily used to estimate the impacts of relatively large schemes. It is not clear that it could equally be applied to small local schemes across all modes or whether the method would have to be adapted to allow for the lack of available data at this level.

4.5.25   Similarly to the other models which have been built commercially, the UDM has been developed by specialists within the owning company. Any guidance documentation rests with the company and is not publicly available. The Intellectual Property Rights also rest with the model owning company.

Known Uses

4.5.26   Examples of application of the UDM include the Leeds TIF bid model, South Yorkshire model, the Merseyside Strategic Model and the West Yorkshire Transport Fund model. The latter involved testing 60 different schemes, which were then ranked by GVA/£capital. The top 27 schemes were then selected, with the criterion of a total capital cost of £1 billion, and tested as a package.

4.5.27   The primary purpose of the model is to test aspects of transport and land-use policy, including:

- Highways capacity and speed improvements;

- New highways;

- Bus and rail improvements;

- LRT;

- Cycle and pedestrian enhancements;

- Smarter choices;

- Parking restrictions;

- Park and Ride; and

- Congestion charging.

4.6   Wage Equation Models

4.6.1   This section focuses on the methods employed using 'wage equation' models. The first section covers a methodology that has been developed and applied by KPMG. This is then followed by discussion of a similar model developed by the Spatial Economic Research Centre (SERC).   The wage equation model shares many of the characteristics of the partial equilibrium model reviewed in section 4.8 below, and there are grounds for treating them as variants of the same approach, based on a common method, namely the relationship between transport connectivity and both urban density and productivity. For the purposes of

this study however they have been assessed separately, in part because the partial equilibrium model described below is derived from the WebTAG Wider Impacts guidance, which forms part of the partial equilibrium framework of conventional cost benefit analysis. The wage equation model has been estimated independently of the WebTAG methods and the estimates in the model of the change in productivity are supplemented by a relationship based on that between changes in transport connectivity and employment density.

KPMG

4.6.2 KPMG carried out work for Greengauge 21 to estimate the economic growth and employment benefits of a national high speed rail network[16]. It has also carried out similar work in other areas, such as that for Greater Manchester Passenger Transport Executive estimating the impact of enhancements to public transport in urban areas. We have had to limit our assessment to published material e.g. the work carried out for Greengauge 21[17]. It should be noted that the work for Greengauge 21 focused on national impacts, although we understand the same type of approach using a wage equation model has been used to look at impacts of transport interventions at a sub-national, regional and local level. Due to the timing of the respective studies, this report was not able to examine the recently completed analysis by KPMG for HS2 Ltd, which involved considerable model development. The following should therefore be read within that context.

4.6.3 The section provides a description of the model, highlights the key aspects of the approach and briefly sets out how the method performs against the criteria.

Summary Description and Theory

4.6.4 The changes to economic activity and growth are driven in the KPMG approach by the changes a transport investment can make to productivity. The productivity improvements identified by KPMG are threefold:

- Changes within particular business sectors;

- Changes in the location of businesses and jobs; and

- Changes in the mix of businesses.

4.6.5 The first of these impacts is created by journey time savings reducing costs and increasing efficiencies of firms. This happens, for example, as the time spent by employees travelling reduces or firms are able to access their suppliers or customers much more quickly. These impacts tend to be captured in conventional transport cost benefit analysis through changes in welfare. In addition, recent developments in transport appraisal mean that spill over or externality benefits, as businesses become better connected, are now captured under the Department's guidance on 'agglomeration' impacts. Again these impacts are related to changes in welfare.

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[16] The work carried out for Greengauge 21 involved analysis of a larger network of High Speed Rail services than that now being considered between London and Birmingham, Manchester and Leeds

[17] (Greengauge 21: Consequences for Employment and Economic Growth, 2010)http://www.greengauge21.net/publications/consequences-for-employment-and-economic-growth/

4.6.6   The second productivity improvement stems from the redistribution of activity. KPMG claims that improving transport connectivity can provide opportunities which lead to businesses locating to more productive areas, such as city centres, or people moving to higher productivity employment. While the move to more or less productive jobs is included in WebTAG under 'wider impacts', the recommended approach captures only the welfare gain i.e. the additional tax revenue paid by the worker delivering the additional output. The full GDP effect of the additional output would, however, be larger than the additional tax / welfare. This is particularly so under a flexible land use scenario as the structure, size and geographic pattern of activity changes in response to an improvement in transport. A flexible land use leading to higher levels of output is a key assumption in the work by KPMG.

4.6.7   The third impact, in terms of changing the mix of business, would stem from transport investment creating national markets and supporting long term structural change in the economy. This could increase rates of productivity growth and economic growth.

4.6.8   In the work carried out for Greengauge 21, KPMG explains that the third impact is excluded from its analysis due to the lack of evidence to support the quantification of the change in sectoral mix. The analysis therefore focuses on estimating how transport investment impacts on the first two productivity changes.

4.6.9   The method that was developed by KPMG to estimate the productivity improvements therefore has two key elements to it. The first element measures the productivity impacts generated by improved connectivity, through say, business travel time saving and agglomeration benefits generally captured in conventional transport cost benefit analysis. The second element involves the productivity benefits associated with the move to more productive business locations and jobs which is additional to that captured using cost benefit analysis.

Model Specification & data – rail supply side and accessibility measures

4.6.10   This part of the model is relatively straightforward in modelling terms. The model used covers England, Scotland and Wales in 408 zones, reflecting administrative boundaries – so the zoning is fairly coarse. There is a very simple treatment of station access and egress – based on assumed 30kph trips from population weighted centroids to stations. A matrix of rail generalised costs has been estimated, using MOIRA and PDFH, together with KPMG's own estimate of fares.

4.6.11   Workplace employment by sector; working age population; and productivity have been estimated by KPMG at the zonal level. The first two were estimated using a combination of Annual Business Inquiry data, Annual Survey of Hours and Earnings data and NOMIS. 'Base case' forecasts to 2040 are estimated.

4.6.12   This specific analysis by KPMG uses 'wages' as a direct proxy for productivity. While this is recognised as a limitation in the documentation, productivity data is unavailable at district level by business sector. KPMG therefore estimated district level measures of wage income by business sector using wage data available by sector at the regional level together with wage data that is available at district level (but not by sector). This was then used as a proxy for the contribution of labour to GVA.

4.6.13   Connectivity measures representing (i) business to business and (ii) business to labour market rail connectivity at the zonal level were developed, broadly like Hansen[18]accessibility indicators. That is, for each zone / defined point in space this measure combines the travel times to each employment 'zone' and the number of jobs at each potential employment location. This measure is weighted in such a way that a more distant job is 'worth' less than a job close by, and more jobs in a given location are 'worth' more than fewer jobs. This measure therefore encapsulates access to all business from a given location. However, the coarse zoning system means that commuting is likely to be fairly crudely represented as most trips will be intra-zonal and will therefore not change with the scheme.

Relationships between rail connectivity & economic outcomes

4.6.14   The relationships between rail connectivity and a) levels of productivity and b) employment density are key to the approach taken and results generated that were in this analysis by KPMG. It has used its base year zonal rail accessibility measures and socio-economic data to examine a number of statistical relationships.

4.6.15   The first of these is business productivity. It found that areas with higher levels of rail connectivity tend to have higher levels of productivity (i.e. wages) with an elasticity of 0.11, i.e. an area with 10% better rail connectivity (business to business) will have wage levels which are 1.1% higher[19].

4.6.16   The analysis assumes that this is a causal relationship, and this assumption is the basis for the estimation of the impact of changes in rail connectivity on productivity (wages). This is an important point, as the analysis assume that because there is a relationship it implies causation i.e. the areas considered have high levels of productivity because there are high levels of rail connectivity, In reality however there is no empirical evidence provided to support this one way direction of causation and it could be that it works both ways i.e. an area has high levels of rail connectivity because the workforce has relatively higher levels of productivity, and in some cases higher levels of productivity because of access to higher levels of rail services.

4.6.17   The second economic relationship is between levels of rail connectivity and employment density (jobs per square km). On the basis of its analysis, the report by KPMG concluded that areas with higher levels of rail connectivity have higher employment densities. Again there is no evidence to support the single direction of causality and that it could work both ways. Providing evidence for direction of causality of impacts is a problem encountered more generally in considering the relationship between transport connectivity and productivity.

4.6.18   On the assumption that there is a causal relationship, an elasticity (of 0.14) is estimated, and the KPMG analysis concludes that employment will increase in areas affected by rail connectivity improvements (i.e. businesses will relocate at the expense of areas which have not seen an increase in rail connectivity).

4.6.19   For both sets of analysis (employment density and productivity) the relationships found are claimed to be statistically significant.

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[18] The Hansen index is measured purely on a time basis, unlike generalised cost which includes time and cost factors.

[19] KPMG also looked at labour market to business accessibility but could not separate this effect from the business to business elasticity

4.6.20   The analysis by KPMG therefore found statistical relationships between wages and rail connectivity, and employment density and rail connectivity. The key assumption made in the analysis is that this is a causal relationship and that improving rail connectivity will cause an increase in wages / productivity and employment density. As explained above, it is perhaps more likely that the direction of causation is two way rather than one way.

4.6.21   KPMG produced a forecasting model, using the elasticities, to estimate the impact of introducing a high speed rail network in the UK. There are three key parts to the forecasting model – where changing rail connectivity influences:

■   Productivity within sectors – included as a national gain, reflecting business travel time savings and agglomeration;

■   Productivity by influencing the sectoral mix – distributional and with no net change in the national GVA figures; and

■   Employment density – also distributional – (but as firms relocate to more productive locations, they therefore become more productive themselves – the areas from where they have moved are losers but there will be a net national gain) – the nature of this redistribution reflects assumptions regarding the mobility of employers by sector[20].

4.6.22   In terms of the impact on net national changes in employment, the impact of improving commuting times to attract people into the labour market has not been accounted for. Neither has the impact on attracting inward investment. The impact on net national employment is therefore based on changes in wages (calculated from the model parameters described above) which attract new entrants into the labour market. These are translated into net changes in national employment by using an elasticity of 0.1. This is the elasticity recommended by the DfT for estimating the employment impacts of changes in the net returns from working.

4.6.23   The changes in rail connectivity associated with HSR are quantified and the knock-on impact on (i) changes in productivity, (ii) net national employment and the (iii) pattern of employment due to redistribution (and the resulting productivity gains) are estimated.

4.6.24   In summary, the analysis by KPMG reports HSR's GVA impact (for the network proposed by Greengauge 21) to be £16.9bn[21] per annum in 2040. This comprises 25,200 new jobs at an average wage of £43,000, plus a 1% wage increase for all existing UK employees (assumed to be around 37m, in 2040). Although in no way comparable to the estimate of the welfare economic benefits of the scheme, the welfare benefits in the separately produced economic appraisal were estimated as having a Present Value of £125.4 billion (including wider impacts). The need to sense check and understand the reasons for such relativities and their meaning is clear.

4.6.25   The benefits estimated in this analysis by KPMG are made up of:

■   Change in rail connectivity – change in productivity (wages) of existing firms – change in GVA;

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[20] This case is also a strong feature of SERC's Structural model based on trade theory (in later chapter). However, Volterra has argued that such redistribution might be from overseas and hence a national gain? See (The Economic Benefits of Crossrail, 2007)

[21] It is worth noting that if GDP was to grow by 2% per annum, this would represent around 2% of GDP by 2050

- Change in rail connectivity – change in productivity (wages) to existing firms – generation of new employment to the area – change in GVA; and

- Change in rail connectivity – change in employment density in affected areas – firms therefore relocate and their productivity improves (i.e. their rail connectivity has improved) – change in net GVA – some areas lose though and no new employment assumed.

4.6.26   This analysis does report winners and losers as a result of high speed rail. It therefore assumes economic activity can move around between different locations. However, there is less clarity on the impact on losers outside of the region under consideration.

Performance against Assessment Criteria:

4.6.27   Overall the method applied by KPMG, in the analysis for Greengauge 21, performed well against the assessment criteria, but there is a key issue with a particular aspect of the approach i.e. the direction of causality.

4.6.28   On the negative side, a number of the impacts may be dependent on other factors occurring, but the costs associated with these are not taken into account. In addition, there is no evidence provided to suggest that the non-transport impacts which the scheme may be dependent on are likely to materialise e.g. the availability of a suitably qualified workforce to take on the jobs that arise, at least in the short term.

4.6.29   In addition, there is no explanation provided for the counterfactual or the impact of the transport proposal on other geographical areas i.e. winners and losers and distribution of impacts. The approach does not consider any non-economic impacts or apply discounting to the economic impacts that materialise over time.

4.6.30   The issue of causality is a key one. As explained above, the KPMG analysis found statistical relationships between wages (and therefore productivity) and rail connectivity, and employment density and rail connectivity. The key assumption is that this is a causal relationship and that improving rail connectivity will cause an increase in productivity and employment density. It is possible that, rather than productivity and employment density being a function of public transport connectivity, public transport connectivity could be a function of productivity and employment density (i.e. more public transport has been provided in areas that have higher productivity). At the very least it is likely that the direction of causation works both ways and no empirical evidence is provided to support the single direction of causality.

4.6.31   The approach relies on the relationship between productivity and urban density. It is therefore better suited to dealing with cases where the mechanism driving change is improved quality of transport for commuting than to long distance schemes where the behaviour of firms via the business travel sector is likely to be key.

4.6.32   Conventional cost benefit analysis generally assumes fixed land availability. If land availability is not fixed then additional capital investment / cost will be needed in line with the increased availability. The approach adopted by this KPMG analysis assumes flexible land use and availability. It therefore needs to take account of the associated costs incurred by developers and other firms in providing for the increase in employment density.

4.6.33   Similarly, if the transport investment acts as the catalyst for economic growth i.e. it is dependent on other factors to achieve the potential increases in productivity and economic growth, e.g. housing, business premises, capital investment, infrastructure investment, then the cost associated with these other factors needs to be taken into account in the estimate of the increase in GVA.

4.6.34   On the positive side, there is a clear explanation of the economic theory and principles that form the framework of the method. It provides a coherent explanation of how the transport intervention is assumed to affect labour supply and how this contributes to higher levels of economic growth and job creation, although there is an issue with the evidence supporting the elasticities.

Spatial Economic Research Centre

4.6.35   The study by the Spatial Economics Research Centre (SERC) *Strengthening Economic Linkages between Leeds and Manchester*[22]investigated economic integration and interaction between the Manchester and Leeds city regions and how improved transport links could support growth in the wider northern economy. The key question tackled was if higher levels of integration between the cities resulted from the improved links, would this accelerate growth in the north of England more generally?

4.6.36   This study by SERC is essentially split into three sections[23].   The first section analyses existing interactions between the two cities to understand if and why these differ in comparison to other city pairs within Great Britain.   In summary, the analysis by SERC concludes that existing commuting between Manchester and Leeds is approximately 40 per cent less than what would be expected, taking account of the distance between the two cities i.e. 40 miles and the individual city characteristics.

4.6.37   The study by SERC also explains that this difference is due, in part, to the transport costs between the two cities as well as the industrial and occupational composition[24]. It adds that lowering commuting costs, via transport improvements, could have an important role to play in improving levels of integration between Manchester and Leeds, and therefore raising the level of economic growth of the two cities.

Summary Description and Theory

4.6.38   Following the examination of the current interactions, the second stage of the SERC analysis involved estimation of the impacts of increasing integration using a wage equation model[25]. More specifically, the analysis considered the productivity benefits generated through higher levels of agglomeration as a direct consequence of better access to economic mass.[26] The study by SERC explains that agglomeration economies are generated because of the production benefits from physical proximity. In line with research findings elsewhere, the

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[22](Strenghtening Economic Linkages between Manchester and Leeds: Feasibility and Implications, 2009)

[23] The first two sections are discussed in this section on the application of the wage equation model. The third section involves the development and use of a structural model which is reviewed in the following section.

[24] SERC does not examine the impact of cultural or social factors on levels of commuting between the two cities, although it suggests that because economic factors explain the low commuting levels this leaves little room for cultural or social factors having a role

[25](Review of Methodologies to Assess Transport's Impacts on the Size of the Economy, 2010)

[26] There is significant debate about whether absolute mass or density is the better indicator of agglomeration.

study explains three sources of agglomeration impacts: linkages between intermediate and final goods suppliers, labour market interactions and knowledge spillovers.

4.6.39   The analysis by SERC uses a wage equation model to estimate how changes in accessibility impact on productivity. However, it differs in three ways however from the method used by KPMG:

■   It uses a measure of accessibility to economic mass, which is comparable to the DfT's recommendation in WebTAG;

■   It distinguishes between accessibility to economic mass by rail and road; and

■   It is estimated using time-series micro-data on individuals and not aggregate data for a locality. Mackie and Laird[27] explain that this means that SERC is able to estimate a fixed effects model and control for individual's characteristics (such as education) as they move between different locations.

4.6.40   When carrying out the analysis, the study by SERC explains that it may be that the composition of the labour market is an important element in the positive relationship between wages, productivity and city size. It may not simply be that people in larger cities have higher wages, and are therefore more productive, but that more educated people, who earn more, work in larger cities and this is the reason why city size is correlated with higher wages.

4.6.41   This analysis by SERC therefore distinguishes between a people-based (or composition-based) effect and a place-based effect. The people-based effect relates to workers who would be higher paid wherever they decide to live but make a choice to work in places with higher levels of economic mass i.e. larger cities. The place-based effect occurs because people in larger cities are simply paid more i.e. people are more productive in larger cities whatever their level of education.

4.6.42   An improvement in connectivity can therefore increase productivity through a people-based effect by attracting more educated people to the area, or through a place-based effect which impacts on agglomeration. It is the latter which represents the net national gain, and therefore it is crucial to distinguish the two effects.

4.6.43   In terms of the findings of the SERC work, it concludes on labour markets and agglomeration that closer integration between Manchester and Leeds could deliver benefits in terms of increased wages – a reduction in train journey times between Leeds and Manchester could generate an increase in wages of between 1.06% and 2.65%. The figures vary depending on an individual's location. However, the study by SERC adds that almost all of the increase in wages is generated by changes to the composition of the workforce i.e. the people-based effect, rather than place-based impacts. The results suggest that for any individual who does not respond to changes in accessibility (e.g. through changes in education, skills or occupation) they will most likely experience smaller rises in wages in the region of 0.20% to 0.50%. The analysis by SERC emphasises that these figures represent an upper bound of the potential impacts, as they cannot discard the possibility that the effect runs from the

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[27] Review of Methodologies to Assess Transport's Impacts on the Size of the Economy, University of Leeds Institute of Transport Studies, September 2010

composition of the labour market to lower transport costs (rather than the other way round)i.e. there is a causality issue similar to that in the analysis by KPMG.

4.6.44   This finding suggests that improvements in transport connectivity and accessibility will have a greater impact if they create, or are at least supported by, structural change, such as the composition and / or ability of the workforce.   Interestingly, the study by SERC discusses whether these wider economic impacts associated with the workforce moving to higher skilled jobs should be counted as additional to conventional user benefits.   It is concluded that:

4.6.45   From a traditional cost-benefit perspective, these effects would not be counted as additional for individual investment projects, as is likely, they come about because of greater attraction or retention of existing skilled workers.   If they occur because existing workers increase their education or skills in response to changing economic opportunities some part of these higher gains may be additional (to the extent that the individual benefits of increasing, say, education outweigh the costs).

Performance against Assessment Criteria

4.6.46   The SERC reduced wage equation model performed similarly to the approach applied by KPMG in terms of its positives and negatives against the criteria.   For example, on the positive side, there is a clear explanation of the economic theory and principles that support the method.   It provides a clear case of how the transport intervention will feed through to impacts on economic growth.   The metrics are also useful in terms of estimating changes in productivity and output (GDP).

4.6.47   The data are all from published sources and full details of the model are published.   In addition, unlike a number of the other model owners, the team responsible for developing the model has no objection to others freely taking these parameters and making use of the model.

4.6.48   It was explained under the discussion on the KPMG analysis that the key concern with the approach was with the direction of causality in the wage equation models.   While there are claims that improved transport accessibility / connectivity will lead to higher levels of productivity / wages / employment density, it is equally plausible that the former could be a function of the latter and that the direction of causality works both ways.   Understanding this is crucial in informing future transport policy decisions and whether they are likely to be effective.

4.6.49   To address this issue, the SERC analysis suggests that account has to be taken of the distinction between people-based effects (composition of the workforce) and place-based effects (agglomeration) when considering the impacts of a transport intervention.   Some methods do not make this important distinction and the people-based effects add to the plausibility of the results.

4.6.50   By redistributing the most productive people it will be possible to affect productivity at the local level, although the impact at the national level will be dependent on the place-based impacts.

4.6.51   While some methods are more suited than others at identifying the redistribution impacts by separating people and place based effects, it is not clear how or whether the areas that lose (as people move to more productive areas) are identified and what the impacts on these

places are (this is partially addressed in the use of the structural model discussed in the next section).

4.6.52   Interestingly, the study suggests that productivity increases stemming from rail investment are likely to have a bigger impact than road investment, but further work would be required to reach a definitive conclusion on this. It also suggests that the 'medium-skilled' workers are likely to be the drivers of changes in productivity. While not necessarily a key factor that needs to be considered by any future method, the point is an important one.

4.6.53   Unlike the KMPG analysis and the use of the partial equilibrium model by Volterra / Buchanan discussed later in this chapter at 4.8, the SERC wage equation model does not provide any estimate of the extent to which increased accessibility increases employment density – the change in the number of jobs in the more accessible zones.   The model focuses on productivity per person. It has not been extended to estimate changes in the number of jobs.

4.6.54   The estimates are claimed to represent an upper bound as some elements of causation remain uncertain. For example, the method does not correct for the possibility that more productive people might encourage operators to provide better transport because of their higher incomes or preferences for high levels of accessibility.

4.6.55   The estimation of the relationship between productivity and access to economic mass is data intensive because of the use of micro-employment data in order to separate the person effect from the place effect. However, once estimated, the relationship can be assumed to hold for all areas of sufficient economic mass.

Known uses

4.6.56   As explained above, the model developed by KPMG has been used to analyse the strategic economic impacts that HSR could have on the national economy, in a study for Greengauge 21.   Other work has included analysis to support the Greater Manchester TIF bid in 2009. These documents suggest that it has been used on a number of other regional studies, but details of that work has not been made available as part of this study.

4.6.57   The work by SERC has been used to examine the benefits from closer links between the cities of Leeds and Manchester.

4.7   Structural Model

Summary Description and Theory

4.7.1   The previous section discussed the use of the wage equation model by SERC to examine the labour market and agglomeration impacts of strengthening the transport integration between Leeds and Manchester. In the final section of that study[28], SERC focused on the distribution of the impacts of strengthening linkages between Leeds and Manchester and, specifically, how the changes might affect the rest of the north of England economy. It undertook this by developing what they referred to as a 'structural model' to gain an understanding of how the

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[28](Strenghtening Economic Linkages between Manchester and Leeds: Feasibility and Implications, 2009)

productivity impacts generated would extend beyond the two cities, and the level of displacement across different areas of the north.

4.7.2   The study by SERC explains that its structural model was developed using the principles from heterogeneous firm trade theory, which examines the effect of trade integration on productivity.   The authors decided against the use of a Spatial Computable General Equilibrium model, which is discussed in section 4.9, due to the strong assumption in these models that productivity and technological innovation are exogenous, while the urban literature assumes that productivity and innovation are endogenous i.e. they are both related to the spatial distribution of firms and workers and that there are large differences across space.   The authors claim that the structural model accounts for these differences, in line with empirical evidence, implying that such an approach should be better suited to estimating the spatial impacts of a transport scheme or policy.

4.7.3   The method assumes that higher levels of integration across regions impacts positively on productivity through higher levels of competition from new entrants to the market and increased trade with new markets.   Prior to a transport improvement some unproductive local firms will be protected against competition in other regions, while more productive firms will be constrained from expanding their production due to difficulty in reaching customers in other regions.   A new transport improvement which reduces costs will therefore expose unproductive firms to new competition and open up new opportunities for more productive firms.   Unproductive firms will exit the market in the face of increased competition, while the most productive firms will expand production.   Overall the transport improvement impacts on competition, which leads to higher levels of aggregate and average productivity.

4.7.4   The model generally predicts that trade integration particularly benefits relatively small regions, due to greater access to larger markets.   However, it is explained that these results are very much dependent on the assumption that workers do not change their location in response to the transport improvement.

4.7.5   The model is used to estimate the impacts of a number of scenarios where journey times are changed: in rail services between Leeds and Manchester; in rail services between Leeds and London and Manchester and London; in the internal transportation networks of both Manchester and Leeds.   It also considers a scenario where the housing stock of both Manchester and Leeds increases, resulting in a) an inflow of workers from the north region of England, and b) an inflow of workers from all over Great Britain.

4.7.6   The results of the analysis using the structural model show:

- Both intra-and inter-city transport schemes deliver positive productivity benefits due to the selection effects as a direct consequence of higher levels of competition. The authors claim that these benefits occur in addition to the user benefits estimated in traditional transport cost-benefit analysis;

- A reduction in journey times from Leeds and Manchester to London generates greater GDP gains than improved connectivity between Manchester and Leeds. However, while the percentage increases in GDP gains are higher in Leeds and Manchester, the size of the London economy means that area receives a larger percentage share of the total gains;

- While the total GDP gains from linking Manchester and Leeds will be lower than from improving journey times from these cities to London, the impacts from the former will be more concentrated in the north; and

- An increase in the population of Leeds and Manchester results in small productivity gains but large total GDP impacts. However, if the increase in productivity comes from attracting labour from other parts of the north, the aggregate gains generated by increased productivity are significantly exceeded by the productivity benefits generated by workers switching from lower productivity areas to the higher productivity areas in Leeds and Manchester.

4.7.7   In summary, the conclusions from the SERC analysis suggest that redistribution impacts can lead to significant increases in local GVA. The SERC structural model however also shows that there will be winners and losers, in terms of GDP changes, at a local level. Mackie and Laird (2010) also conclude from the SERC results that while the total economic impact predicted by the structural model can be significant, the impact on average wages is lower than that forecast by the wage equation model. This therefore suggests that redistribution and changes in the supply of labour have a greater impact compared to changes in average productivity.

Issues for consideration

4.7.8   The wage equation models do account for some redistribution of activity. However, there is limited analysis of the precise impact on the regions from where productive people move following the improvements in transport. The structural model attempts to counter this by providing greater understanding of the redistribution of activity and identifying the winners and losers and the changes on the local / regional economies. As the focus of the model is primarily on the redistribution of activity it is not assessed against the criteria.

4.8   Partial Equilibrium Models

Summary Description and Theory

4.8.1   The approach used by Volterra / Buchanan (V/B) in their 2007 paper on estimating the economic impacts of Crossrail[29] is derived from the analysis later published in the WebTAG Unit 3.5.14 guidance on Wider Impacts. The WebTAG Unit provides guidance on estimating the welfare benefits of the effects of changes in transport generalised costs on agglomeration and the effects on labour supply and labour productivity. The labour market impacts are derived both from a direct labour supply effect in response to the reduction in the cost of travelling to work, and from a shift by employers and hence by employees to more productive locations[30].

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[29](The Economic Benefits of Crossrail, 2007)http://www.crossrail.co.uk/assets/library/document/t/original/the_economic_benefits_of_crossrail-october_2007.pdf

[30] The welfare benefits from the Imperfectly Competitive Markets impacts in WebTAG Unit 3.5.14, which are on account of the market imperfections caused by the cost/price mark-up described, are a pure welfare effect and have no bearing on the GVA related wider impacts.

4.8.2   The V/B method applied in this instance has, as far as we are aware, been applied only in the case of London schemes and the only documentation we have seen describes its application to Crossrail[31][32].

4.8.3   The V/B approach that was applied for Crossrail uses estimates of the agglomeration benefits, which were calculated initially prior to the release of the WebTAG guidance on agglomeration.   The approach applied different and higher London specific values for productivity by sector than in the DfT WebTAG guidance.   However, as with the WebTAG guidance, the agglomeration benefits in the V/B approach are regarded as reflecting the increase in GVA per employee in dense urban areas caused by an increase in effective density, as measured through changes in the generalised cost of travel between zones in that area.   The evidence from the relationship between effective density and GVA by sector shows that this relationship declines sharply with distance from the zones with the highest employment densities.   There are several causes of agglomeration benefits, including the opportunities for deeper and more effective markets in matching people and firms, goods and services with consumers, for sharing public goods and for knowledge spillovers.   The welfare based measure of the agglomeration benefit is identical to the GVA measure used in estimating a scheme's impact on local economy.   The additional output, measured in terms of an increment to GVA, increases economic welfare because the additional goods and services, in the hands of consumers, increase individual's utility and hence overall economic welfare.

Labour supply

Increase in Labour Force Participation

4.8.4   The analysis by Volterra and Buchanan follow WebTAG in identifying two ways in which labour market responses to the reduction in transport generalised costs increase London's GVA.   The first response is the increase in participation in the labour force.   Evidence from labour market studies[33]show that labour supply responds to changes in the cost of participating in the labour force.   If the generalised cost of travel to work is included as one of these participation costs, then improvements in commuter services can be expected to increase the labour supply.   Labour supply elasticities are provided in the WebTAG Unit 3.5.14 on Wider Impacts and these same elasticity values have been taken to estimate the GVA on account of Crossrail's impact on participation in the labour force.

4.8.5   WebTAG, being concerned with the welfare impact of the individual's decision to join the labour force, counts only the additional tax paid by that individual as the economic benefit. Since the individual was free to participate in the labour force in absence of the scheme and chose not to, the cost benefit approach assumes that, as far as the individual is concerned, the welfare costs of working were equal to or more than the benefits of being employed. With the decision to join the labour force triggered by the reduction in transport user costs, the benefit to the individual is measured in the cost benefit analysis through the conventional rule of a half.   But the benefits to society are greater, since the individual generates when working revenue from income and other taxes from which she gains no direct benefit.   In

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[31](Crossrail: Socio-Economic Technical Report, 2005)http://www.crossrail.co.uk/about-us/crossrail-bill-supporting-documents/specialist-technical-reports/?folder=/l0/228

[32](The Evolution of London's Crossrail Scheme and the Development of the DfT's Economic Appraisal Methods, 2011)http://www.internationaltransportforum.org/jtrc/DiscussionPapers/DP201127.pdf

[33](Transport, Wider Economic Benefits and GDP, 2005)

terms of a GVA effect, the whole of the gross income of the individual induced to join the labour force on account of the reduction in transport user costs is counted, as the GVA metric ignores the welfare cost incurred when the new worker changes from a life of leisure to one of work.

Move to More Productive Jobs

4.8.6   A second consequence of the reduction in transport costs on the labour market is the redistribution of jobs between zones. Firms with employees in the higher value added sectors are induced to relocate to zones benefitting from transport improvements, a movement offset in part or in full (depending on the assumptions about employment growth in the transport model) by lower productivity firms moving to locations where rents are lower. Since WebTAG, when estimating the welfare impact of such changes, takes a national perspective, the effects on the overall level of employment net out as a shift between locations. However, because the firm which moves to the urban area belongs to a sector which gains more from the relocation in terms of additional productivity than is lost by the firm which moves out, there is an overall gain in productivity. In estimating the welfare benefits, WebTAG counts only the additional tax receipts and the transport user benefits (through the rule of a half) for the reasons set out in the discussion of the labour supply elasticity effect. The implicit assumption in this measure of the welfare benefit of the move to more productive jobs is that individuals in the relevant sectors could always have moved to the more productive jobs in the sectors in which they worked prior to the transport scheme but were only induced to do so by the scheme. A measure of the impact on GVA includes all of the net additional productivity.

4.8.7   WebTAG advises the use of a LUTI model to represent the relocation of economic activity on account of a change in transport user costs within an urban area. The use of LUTI models to provide estimates of local economic impacts is covered elsewhere in this report.

4.8.8   V/B lacked an appropriate LUTI model when estimating the impacts of Crossrail for their 2007 paper. They used instead a model based on the relationship between growth in commuting volumes and the level of crowding on each route. Crowding acts as a constraint on growth and the effect of Crossrail on that constraint will be to facilitate an increase in commuting flows. V/B make certain assumptions about the extent to which these employees who are new to London (where they are more productive than in their previous location) are people who previously worked elsewhere in Crossrail's catchment area in less productive jobs and how many are new migrants to England, attracted from overseas by the improvement to London's transport infrastructure. The GVA impact counts all of the GVA added by new migrants, whereas for those who are part of the indigenous shift of jobs between locations, the impact is the difference between their productivity in London and their productivity in their previous work location.

Performance against Assessment Criteria

4.8.9   The partial equilibrium approach described above performed well against the assessment criteria. On the positive side, there is a clear explanation of the economic theory supporting the approach, which is consistent with the theory set out in the WebTAG guidance on Wider Impacts. In many cases the approach is supported by empirical evidence, as well as indicating the uncertainties associated with the evidence. Sensitivity analysis was conducted on the key assumptions. Other positives included: it explains how the transport intervention impacts on labour supply and how this contributes to higher levels of economic growth; there is a clear explanation of the elasticities supporting the analysis and the evidence behind

these; an explanation of the counterfactual is included; assumptions used are well documented; account was taken of displacement and additionality; and it is the only approach considered in this review which clearly applies discounting to impacts generated in future years, although this is possible with the land use-type models which generate forecast impacts on an annual basis.

4.8.10　On the negative side, there is no explanation provided about the dependency on other factors occurring. In addition there is no information on the availability or weakness of data or the limitations with the approach. No account is taken of the non-economic impacts.

4.8.11　The V/B approach applied to Crossrail, in common with the DfT Wider Impacts guidance, focuses on transport schemes serving urban areas.

4.8.12　The V/B approach for Crossrail takes no account of the indirect effect of transport cost changes on the wider economy, as would a SCGE model which is discussed in the following section. The WebTAG unit on which the V/B approach is based was aimed at addressing the wider welfare benefits and the direct effects – or at least their first round effect – are identified in the standard analysis of the transport user benefits. The V/B approach makes no attempt to take account of consumer's responses to the additional output produced and demand is assumed to be perfectly elastic. SCGE models are based on profit and utility maximising decisions by firms and by consumers in response to transport cost changes and the interaction between these agents, hence the distinction between a general equilibrium approach and a partial one.

Known and Intended Uses of the V/B approach

4.8.13　The V/B approach was used in the 2007 Report by Volterra Consulting Ltd and Colin Buchanan, updating and developing a 2002 report. The approach has been updated further in presentations given by Volterra Consulting Ltd. We are not aware of other uses of the method.

4.9　SCGE Models

Summary Description and Theory

4.9.1　In theory, Spatial Computable General Equilibrium (SCGE) models might be considered as providing the most comprehensive framework for modelling the local or regional impacts of an intervention in the transport sector. This class of model aims to provide a thorough analysis of the impacts of spatial policies such as land use changes and transport schemes on the economy of a region, depending on the economic relationships incorporated into the model. For example, the approach has two potential strengths that are lacking in the other models reviewed. The method represents all agents within the economy, both households as providers of labour and owners of land and capital, and the firms which produce the goods and services consumed by households. Unlike traditional general equilibrium models of an economy, economic activity takes place across space and hence the model allows for both the geographical distribution and overall level of activity to be influenced by spatial policies and changes in transport costs. SCGE models share the theoretical basis of the more general national or regional economic model of the workings of the economy, with the addition of identifying the location of where economic activity takes place and the sensitivity of the level and location of those activities to changes in transport costs.

4.9.2   By including households as consumers with a household utility function in the model, the equilibrium basis for the approach provides a significant theoretical advance on the methodology of the wage equation or partial equilibrium approaches. It would provide a 'whole economy' GDP based measure in place of the consumer surplus metric which is the output of a cost benefit analysis. Profit maximising firms trade with other firms and supply goods and services to consumers, who pay for these outputs from the income they have earned from selling their labour and renting out their land and capital. Many of these transactions involve a transport cost and hence the approach is well suited to representing the responses firms and households make, through their profit and utility maximising objectives, to changes in transport costs or other spatial policies.

4.9.3   Some SCGE models assume all firms are perfectly competitive. Others assume a version of imperfect competition under which the products that firms produce compete both on price and on variety (which differs by location of production) in households' utility functions. SCGE models also often include a government sector to complete the model of the economy and to permit the inclusion of any public funding of a transport scheme.

4.9.4   Land rentals also vary by location according to accessibility and hence change in response to changes in transport costs. By introducing into the framework a number of separate zones and flows of goods and services and labour and capital between those zones, the method provides estimates of changes in the spatial distribution of economic activity, and is better able to represent the impacts of transport projects and policies than would a regional macro-economic model that lacked the spatial dimension.

Performance against Assessment Criteria

4.9.5   On the positive side, the theoretical underpinning of the model is based on conventional macro-economic theory and on the evidence upon which such economic models are based, supplemented by estimates of changes in transport costs and the impact of such changes on the level and distribution of economic activity. Nevertheless, the complexity of any developed economy, when augmented by a spatial dimension, makes any description of the functioning of the model, such as in the case of the EU Integrated Appraisal of economic and Network effects of transport investments and policies (IASON[34]) project, lengthy and difficult. SCGE models help to show how the impacts of a transport intervention are dependent on other factors within the economy changing, in order for the change in output to be realised, and how these materialise. The method also takes account of impacts on winners and losers across different areas, although this might be biased by the assumption that all land and capital is directly owned by households.

4.9.6   On the negative side, there is limited explanation of the empirical evidence supporting the claimed impacts of the SCGE approach or any sensitivity tests carried out. It is also not clear what elasticities are used in applying the method and the evidence to support these. In addition, there could be data issues, both in terms of the amount of data required and the availability of data at the required geographical level.

4.9.7   In particular, the data requirements for an operational SCGE model are very substantial, both in terms of the exogenous inputs to the model (and the forecasts of these), and in terms of the coefficients in the model. Even if coefficients for firms' production functions and

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[34] Integrated Appraisal of Spatial economic and Network effects of transport investments and policies, European (5th RTD Framework Programme, 2001-2003 http://www.transport-research.info/web/projects/project_details.cfm?ID=5627

household utility functions can be obtained from other sources, estimating the equilibrium response to transport cost changes presents a significant challenge.

4.9.8 A further problem in making SCGE models operational is the spatial coverage of the data needed to populate the model. Transport models tend to operate at a much smaller area level than is generally available from regional or sub-regional economic datasets. Similarly to many other methods, the essentials of a SCGE model are the trade flows (in goods, services and workers) between regions, the costs of which change with spatial policy interventions. But the main effect of many transport schemes is on the flows within a region or sub-region for which the economic dataset is available and the impact on the inter-regional trade flows that provide the data input to the model is often small.

Known uses

4.9.9 With the exception of Spectra, described below, there are no known uses of SCGE models in the UK. In response to the SACTRA 'Transport and the Economy' (1999) report[35], the DfT commissioned a report on the potential for developing a SCGE model. The paper[36] concluded that, without much better regional accounting data, it would not be feasible to use SCGE approaches in UK practice. The paper reviewed the use of SCGE modelling elsewhere. Although a number of models have been developed, among the most advanced of which are EU-funded CGEurope and IASON projects and the Dutch RAEM model, all of these are still at the experimental stage.

4.9.10 In a more recent paper the researchers responsible for RAEM [37] reported that: *"After two years of development and application of SCGE models for transport appraisal, we found that the translation of theory behind the spatial equilibrium models into practical model specifications and empirical applications is a challenging task, and may lead to problems in project appraisal in terms of inaccuracies in the assessment of impacts."*

4.9.11 Despite these reservations, a number of countries, including the Netherlands and Australia, have made use of SCGE models to illustrate the spatial impacts of high level transport policy options, such as the provision of high speed rail links. SCGE modelling remains a methodology under development even in those countries that have better data on regional economies and their differences than is available in England.

SpECTra

4.9.12 SDG's SpECTra model represents a first attempt to apply a full SCGE model to the analysis of transport schemes and policy options in England. The model is still under development and the brief reports that have been provided to us, while providing a clear overview of the framework used by the model, give no details of the evidence or data sources used to support the model[38]. As might be expected, the model is very simple in its representation of the economy of the study area, while containing detail of sufficient categories of firms and

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[35] (Transport and the Economy, 1999)http://webarchive.nationalarchives.gov.uk/20050301192906/http:/dft.gov.uk/stellent/groups/dft_econappr/documents/pdf/dft_econappr_pdf_022512.pdf

[36](SCGE Models: Relevance and Accessibility for Use in the UK, with Emphasis on Implications for Evaluation of Transport Investments, 2004)http://www.dft.gov.uk/pgr/economics/rdg/coll_scgemodelsrelevanceandacces/modelsrelevanceandaccess3116.pdf

[37] (Challenges in the Application of Spatial Computable General Equlibrion Models, 2011)

[38](Spatial Economic Consequences of Transport (SpECTra) (PowerPoint slides))

their products, workers/households and locations as ensure a functioning model which provides a plausible and complete analysis of the economic impacts of a range of policy options.

4.9.13 In simple terms, SpECTra is a sub-regional economic model developed to help understand how time and cost savings delivered by transport investment affect a local economy. It takes outputs from a transport model and simulates the consequences for market transactions between economic sectors and households through changes in productivity, prices, wages, output and the use of labour.

4.9.14 Like any SCGE model, SpECTra comprises sectors or firms employing factors, in terms of labour, capital and land 'rented' to these sectors by households. Households and firms are identified by the zone in which they are located. Recent versions of the model have two or three zones; for example, as applied to Cambridge, the model features a city centre, the suburbs and the rest of the country (RoUK). Households earn income from selling labour and renting land and capital purchase the goods produced by the different sectors. Sectors sell a composite product either directly to households or to other sectors, for incorporation in their own composite product.

4.9.15 SpECTra splits production into 8 sectors - and labour into nine different types. Each sector buys a different labour mix. The location of production depends on relative costs of central or suburban locations, which is affected by supply and demand for land (and workers' wages?). RoUK buys from and sells to the city and suburbs. There are six types of floorspace located in each zone in the model and each sector type requires a different type or mix of floorspace. Each zone trades in composite products with each other zone and with RoUK, with the trade being either between sectors or between sectors and households, and labour and capital move between zones.

4.9.16 Spatial policies such as changes in transport costs or in the availability of land result in cost changes which, by affecting different sectors by different amounts according to the cost of transport in their composite product and their responsiveness to these changes, alter the location and level of economic activity in the study area. In addition to the initial response of the product market, changes in commuting costs affect the supply of labour, hence reinforcing the initial effects of the policy. Labour moves within the Travel to Work Area but does not commute to jobs in the RoUK. A further effect takes place through changes in land rentals in response to changes in land supply or in accessibility.

4.9.17 The descriptions of SpECTra that we have seen are restricted to two presentations demonstrating the functionality of the model in the context of hypothetical transport and land use policies for the city of Cambridge and for an illustrative two zone city and suburb model. The results of the options tested show that, despite the complexities in setting up even a simple SCGE model, SpECTra is operational and produces plausible results which are demonstrably consistent with CBA outputs. In terms of metrics, SpECTra estimates changes in employment, productivity, output (GDP / GVA) and incomes.

4.9.18 We have not seen any documentation of the data used to populate the model or evidence of the validity of the relationships within the model. We note, however, the substantial research effort and funding that has gone into the development of SCGE models in other countries, most of which are smaller than England and have significantly better data on regional output, consumption and trade. SpECTra is a development by a private sector transport consultant and has not benefitted from the resources that have enabled SGCE

models in certain other countries to progress beyond the developmental stage. The development of a demonstration model is of interest as a means of illustrating the complex interactions, many of which are omitted from the other approaches covered in this review. Further development of this model is likely to be constrained by lack of data, of which the absence of good information on inter-regional trade flows would seem to be the biggest gap.

5   Summary and Conclusions

5.1   Introduction

5.1.1   The previous chapter provided an assessment of the methods which are being used, or could potentially be used, to estimate the economic impacts of a transport intervention at a sub-national, regional and local level. This Chapter summarises the strengths and weaknesses of the approaches that have been reviewed and highlights any key gaps in the evidence. It also sets out the conclusions of the research and identifies issues that would need to be tackled in moving forward to deliver a method that is able to estimate the sub-national impact of a transport scheme on a consistent basis across different types of schemes.

5.2   Key Considerations

Survey Based Economic Impact Models

Strengths

5.2.1   This method provides a simple method for estimating employment impacts as a direct consequence of a transport intervention, and is intuitive in linking transport improvements to jobs 'created' and local GVA

5.2.2   It is much less of a 'black box' compared to many of the other methods which are very complex, difficult to understand, and not necessarily based on more robust empirical evidence.

5.2.3   It is applicable to a wide range of small schemes aimed at releasing local transport constraints, and guidance on this method could also be further developed to provide a more consistent approach to estimating the economic impacts of small schemes.

Weaknesses

5.2.4   The causation – i.e. that the transport scheme is solely (or even partly) responsible for 'unlocking' development and or any increase in activity in established firms – is sometimes difficult to establish. However WebTAG 3.16D on transport appraisal in the context of housing development explains the processes to work through in the case of housing developments, and this could be followed in any future guidance on applying these methods to economic activity.

5.2.5   The approach does not include any consideration of the other measures needed to deliver the development package facilitated by the transport scheme and their costs, some of which might fall on the local economy (e.g. training local workers).

5.2.6   The uses of the method have focussed on local impacts and take little, if any, account of impacts outside of the area concerned. The current approach does not generally make any allowance for displacement or provide a means of estimating the net national impacts.

5.2.7   Similarly, because of the local focus, there is limited recognition of the 'Two Way Road Effect' – respondents to surveys may be unlikely to recognise potential of increased competition from outside the study area. Even if interviewers had access to data on production costs outside the study area, it would not be easy for them to suggest to respondents that better transport links might put them out of business. Additional surveys would need to be carried out beyond the local area. The approach is therefore more suited to one that 'unlocks' new development than improving linkages between two urban areas.

5.2.8   The approach is dependent on survey evidence which can be prone to elements of bias.

5.2.9   It is common practice to use multipliers in this method. The evidence supporting the multipliers is weak, in particular the extent to which the additional jobs are created within the local area. At best, any additional jobs 'created' by the first round effect will be largely transfers from elsewhere, since any spending that results in more jobs in areas of structural unemployment will result in a similar multiplier effect.

5.2.10   Many of the applications of this approach have used employment densities by type of premises to estimate the change in employment. The recommended figures do appear to require more evidence to support their accuracy and robustness.

5.2.11   The approach is more suited to small schemes than to larger ones. Measuring the impacts across a wider spatial level is much more difficult to predict with confidence and much more data and survey evidence would be required across a larger area.

Regeneration Impacts and Economic Activity and Location Impacts

Strengths

5.2.12   The DfT Regeneration Impacts and the Scottish Government's EALI frameworks are similar to the survey-based approach outlined in the previous section. However, they involve a more structured approach which enables them to deal (partially) with a number of the potential weaknesses identified in that approach.

5.2.13   The analysis is based on empirical evidence gathered through surveys of affected firms in the area (although this can also be a weakness). Both approaches also take account of the potential uncertainties around the analysis, such as the impact of the current situation as well as the impact generated by the intervention. The frameworks for carrying out the analysis therefore recommend risk and sensitivity tests to determine the impact on the base-case results.

5.2.14   Similarly to the previous method considered, the framework recommended in the national guidance is less of a 'black box' than many of the other methods assessed, and the guidance on application of these methods sets out an explanation that empirical evidence obtained should be clearly documented.

5.2.15   The EALI approach in particular involves wider coverage than the relatively simplistic survey-based approach and takes account of factors such as: gross and net impacts and therefore how the scheme impacts on the national and local areas; distribution inside and outside of

the local area and also who are the winners and losers and how activity is displaced; it aims to cover intra-area and inter-area trade and the 'two-way road' effect.

5.2.16   Unlike many of the other methods, applying the EALI framework involves identifying other initiatives required to ensure the benefits generated by the transport improvement materialise.

Weaknesses

5.2.17   This approach can involve significant resource to estimate the impacts of large schemes, though there are a number of examples of the method being used for large capital infrastructure projects across Scotland, including the impacts of strategic rail and road networks.

5.2.18   While it has certainly been used to estimate the impacts of large capital infrastructure projects, it is probably best suited to relatively small schemes.   This is because of the significant data resource required, albeit not necessarily less than that required for a number of the other methods assessed in this report.   Not all of the data required is available at the relevant disaggregated level.   It is likely to be less appropriate for inter-urban schemes serving a large number of business users with complex production patterns or with a substantial proportion of business and service sector users.

5.2.19   The survey data collected for this approach could also be subject to bias, and the extent of this will depend on how the surveys are designed and implemented. This is an issue that needs to be considered for all surveys.

5.2.20   These methods are based on assumptions regarding the impacts on local and regional economic activity that are generated by an improvement in accessibility.   The evidence for the strength of these impacts would benefit from further development.

LUTI Models

Strengths

5.2.21   Where a LUTI model is being used to supplement the transport model and appraisal, the incremental costs of adding a GVA module are low because the LUTI model provides an estimate of the likely changes in the location of economic activity which, when linked to an estimate of the average wage per job relocated, accounts for much of the GVA impacts (the others being dependent on changes in agglomeration).

5.2.22   A LUTI model is a valuable tool for estimating impacts that are omitted from a conventional transport model and can then feed information on responses back into the transport model: other approaches to estimating GVA effects fail to provide this additional benefit. It can help to indicate some of the additional measures that are needed to deliver the changes in the location of economic activity.

5.2.23   A LUTI model shows the full effects of the redistribution of jobs away from zones which become relatively less accessible and into those with increased accessibility, thus identifying both gainers and losers.

5.2.24   The mechanisms within a LUTI model are transparent and open to sensitivity testing.

Weaknesses

5.2.25   LUTI models generally do not allow at the aggregate level for an increase in the labour force or in participation because of the transport scheme, an assumption which is adopted by most transport models (despite the labour supply elasticity of 0.1 that is provided in the WebTAG guidance on Wider Impacts). However, they do allow for both effects at local level through redistribution.

5.2.26   LUTI models are complex, can require significant amounts of data (though most of it is readily available from standard sources) and in most cases need to be developed and maintained by specialists, which limits the current potential for wider application of the method. Using existing LUTI models could be expensive and require licenses or be heavily dependent on the model owners, although greater use and application of the LUTI methods could lead to increased knowledge and a wider skill base and potentially reduce costs in the longer term.

Urban Dynamic Model

5.2.27   The UDM simulation approach shares a number of the features of, for example LUTI and SCGE models, as it represents the pressures for changes in land use following changes in transport costs. It integrates the responses to changes in transport costs in a number of markets including housing markets, labour markets, business location and changes in the level of economic activity in the study area.

Strengths

5.2.28   The approach seems well suited to analysing the interaction between overall local strategies, transport schemes, and land use planning constraints. It uses empirical evidence to simulate how individuals, businesses and developers behave in response to changes in attractiveness in conditions. The model tends to be calibrated against observed data for the particular target area (time series and cross sectional) with many of the parameters used in the business and employer model estimated as part of an earlier study for DfT. The metrics generated by the approach can be calculated annually over a number of years and can therefore be discounted to a present value to compare impacts across a range of interventions. The model also provides impacts on other areas to allow estimation of the net as well as gross results across the various metrics and can therefore be used to estimate the gross and net impacts of an intervention and therefore who are the winners and losers.

Weaknesses

5.2.29   The UDM is a wide-area strategic model and has been used primarily to estimate the impacts of relatively large schemes. There could be difficulties in adapting it to apply to small local schemes.

5.2.30   The model has been developed for commercial use and is the intellectual property of the model-owning company. It is unclear whether the specialist knowledge to maintain and run the model would be shared with others if it was to be used more widely. The model owners have explained that they have provided training to clients to enable them to understand and operate the model, but it is likely that the model owners would be required to maintain and develop the model for its suitable application.

Wage equation models – KPMG model for Greengauge 21

Strengths

5.2.31   This is a practical, operational method. It provides information on impacts by zone to demonstrate economic impacts, although examples of its use in analysing local schemes were not provided to us.

5.2.32   There is well documented evidence on the linkages between transport connectivity and productivity and employment density, although causation is not established.

5.2.33   The approach provides an estimate of the local increase in GVA based on both the increase in output per employee and on the increase in the number of employees attracted to the conurbation.

Weaknesses

5.2.34   The method as applied to High Speed Rail for Greengauge 21 provides an estimate of the GDP effect at almost 2% of 2040 GDP. Although estimated on a different basis, this seems implausibly high.

5.2.35   There is no evidence that the direction of causation claimed in the model between an increase in rail connectivity and increases in productivity, employment density and GVA has been established. The likelihood is that the direction of causation is two-way and the implication of this for the outputs, together with their robustness, is crucial.

5.2.36   No explanation is given of the original locations of those jobs that shift to zones benefitting from a transport improvement which account for the change in employment density part of the GVA impacts.

5.2.37   The finding that the productivity elasticity for rail is significantly higher than for road is not intuitively obvious, but this is an important finding and further work is required to determine whether this is actually the case.

5.2.38   It is not clear that the WebTAG employment elasticity (0.1) applies to high GVA jobs (despite WebTAG guidance), jobs of the type which in this model respond to the increases in accessibility, or that it applies to wages plus generalised travel costs, since the labour economists who estimated it would have used only post-tax wages as the independent variable.

5.2.39   The approach is applicable to urban schemes or ones that serve urban areas. However, it is not well suited to interurban highway projects, which tend to serve areas outside urban agglomerations, and takes no explicit account of freight flows.

5.2.40   The KPMG approach applied for Greengauge 21 fails to separate the place-based effect from the people-based effect which (see below) may be particularly important for its robustness.

5.2.41   It provides an estimate of the potential of a transport intervention, but it does not identify the additional interventions, such as workforce training and new office developments, needed to deliver the forecast growth in GVA.

5.2.42 In the application of the model that we have had access to there is no identification of the losers and it would seem that this could only be done through some separate modelling approach.

5.2.43 In common with several of the approaches reviewed, it is a bespoke model developed by the consultant as a commercial venture. There can be issues with commercial licences and intellectual property rights that may restrict the ability of users to apply, maintain and develop such models, and that would need to be considered before any wider roll out.

Wage Equation Models – SERC

Strengths

5.2.44 From the approach reviewed, the economic principles of transport, density and productivity are clear and the identification of the importance of the 'people' based effect adds to the plausibility of the results.

5.2.45 It identifies part or much of causation successfully by separating the people from the place effects.

5.2.46 The data are all from published sources and the team responsible for developing the model have no objection to the parameters being freely used.

Weaknesses

5.2.47 The results from the model are claimed to represent an upper bound as some elements of causation remain uncertain. Further work is therefore required to understand the robustness of these results.

5.2.48 The approach is very data-intensive because of the use of micro-employment data in order to separate the people effect from place.

5.2.49 It does not identify the losers – those zones from which the more productive workers move to the conurbation, implicitly replaced in the model by less productive workers who leave the conurbation to balance the fixed number of jobs in the conurbation.

5.2.50 The work is clearly an academic study – it has not been tested other than in the Northern Way study.

SERC Structural Model

Strengths

5.2.51 This approach represents a realistic attempt to model the 'real economy' with firms of differing efficiencies operating within the economy. Reductions in transport costs put the least efficient firms at greater risk of closing down, while offering better opportunities for expansion to smaller more efficient firms.

5.2.52 The approach shows winners and losers by sector and location.

5.2.53 The approach would seem to be applicable to all types of major scheme or policy and not restricted to urban projects.

5.2.54   The method is very data intensive.

5.2.55   The development of the structural model was an academic study, focused on constructing a theoretical model to measure the distributional impacts of a major transport intervention. The research team responsible for the work claim that the evidence base is weak and insufficient for policy applications.

5.2.56   The approach is inconsistent with the assumption in conventional transport appraisal of perfect competition in the transport using market. If the approach were to be adopted, there would be strong grounds for reconsideration of the measurement of WebTAG transport user benefits and perhaps the imperfect competition element of wider impacts (WebTAG 3.5.14).

Partial Equilibrium Model

Strengths

5.2.57   This method, which was used to estimate the GVA impacts of Crossrail, is generally consistent with DfT advice in WebTAG (but taking all GVA added rather than just the tax wedge as is required in WebTAG to estimate the welfare based measure). Because of this, the linkages between the transport scheme (the economic case) and increases in GVA (the strategic case) are clearly specified, either in the V/B report itself or in WebTAG. In addition causality is explained, with agglomeration and increase in labour force participation being based on WebTAG.

5.2.58   Data are derived from WebTAG, published data, augmented/amended to accord with V/B's views of the appropriate values for London, with evidence to support these.

5.2.59   While no LUTI model was available, analysis of corridor crowding constraints is a plausible alternative and is supported by evidence. The WebTAG guidance on Wider Impacts i3.5.14 does not provide detailed advice about how a LUTI model should be used, so the use of this approach provides one way of addressing the problem.

5.2.60   The approach can identify change in GVA by transport model zone and local authority, a functionality which is useful for demonstrating impacts.

Weaknesses

5.2.61   The crowding off/employment suppression model used to show the impact of Crossrail in relaxing this constraint is not consistent with the treatment of crowding in the CBA and transport model, in which crowding does not actually suppress the exogenously determined number of workers. This is more a weakness of the transport model however. Further 'validation' of this suppression model against transport model crowding costs would be desirable, since the suppression is assumed to be absolute rather than related to (steeply rising) generalised costs.

5.2.62   The move to the more productive Central London jobs part of the model is a major source of GVA. Although no assumption was made in the economic case for Crossrail about the proportion of jobs which shift to London that are filled by workers from other countries, the GVA impact of these shifts is substantially greater than in the case of jobs which shift from elsewhere in the UK because there is no offsetting reduction in the zone from which the job

has transferred. We understand that analysis has now been undertaken to provide an estimate of the extent of the take up of jobs by workers from outside country.

5.2.63 The WebTAG labour supply elasticities are not differentiated by sector or geographical area. They do not necessarily apply specifically to high wage Central London jobs. However, this is an aspect of the relevant WebTAG guidance and not specific to the V/B approach. Both this assumption and the movement to more productive Central London jobs assumption need challenging and stronger evidence to support them.

5.2.64 The method does not allow for changes in the housing market, to reflect, for example, an increase in the proportion of Central London workers living in central and inner London who do not depend on crowded rail corridors London as a response to increased rail crowding.

5.2.65 The movement to more productive Central London jobs part of the model – the constraint released by more rail capacity - is probably applicable to London, and particularly Central London where road has a low market share and so absolute constraints can be estimated (road capacity constraints are less absolute). So, in its current form, the approach is not for general application.

5.2.66 It appears that estimates of the GVA added by additional Central London jobs assume that each new worker induced to work in Central London because of the scheme is as productive as existing Central London workers. WebTAG shows new workers as less productive. It may be that where a constraint on capacity exists, the assumptions in WebTAG may no longer hold.

Spatial General Equilibrium Models

Strengths

5.2.67 In theory this is a comprehensive, if complex, approach to estimating the impact of changes in transport costs on both firms as producers and households as consumers and including changes in these costs on households as suppliers of labour. The SCGE model shows how, with changes in transport costs affecting firms and commuting costs in different ways, the spatial distribution of households and economic activity will change in response to utility and profit maximising behaviour on the part of those agents.

Weaknesses

5.2.68 As far as England is concerned, the data do not exist that would be needed to establish a SGCE model at a level of spatial disaggregation which could serve to demonstrate the sub-national, regional and local impacts of transport scheme.

5.2.69 The cause of economic growth in a SCGE model is through reductions in transport costs leading to reduced costs of output, changes in output and in demand and changes in location. SCGE models in general are not well suited to estimating the impacts of transport cost changes on many of the service, financial and other business sectors for which data are not available on the role of transport costs in their production functions. Nor do they (generally) allow for agglomeration and other place-related impacts that form the basis of the wage equation model approach, although the continually developing SpECTra model, in contrast, does allow for a number of these impacts, including agglomeration. So many of the impacts of transport schemes on an urban economy identified in the partial equilibrium

and wage equation approaches are not generally included in an SCGE model. The approach would seem to be best suited to economies where freight transport costs are significant.

5.2.70   Integrating the outputs on changes in transport costs derived from a transport model with the spatial representation of transport costs in the SCGE model has proved a challenge in those countries which are developing such models because the zones in the model of the economy are generally of the orders of magnitude larger than the zones in the transport model. SCGE models are better suited to testing broad policy options or perhaps packages of major projects rather than the typical urban or interurban scheme for which new guidance is required.

5.2.71   The only example of a SCGE model for use in England is SDG's SpECTra model, which is at present at a stage of development which demonstrates this relatively simple three-zone version of a SCGE model is operational. It is not clear whether the advances that have been made in some other countries in developing an SCGE model for the analysis of transport strategy could be repeated in England or whether constraints on the availability of data, such as information on inter-regional trade, would inhibit such progress.

5.2.72   A further consideration concerns the matching of the regional coverage of any SCGE model and the geography of the city regions or other combinations of local authorities which have an interest in the impacts of a transport scheme. The City regions cover areas which are smaller than the English regions, and so require information on economic impacts at a finer level of detail than could be provided by a series of regional economic models linked by the transport network. It is not clear whether it would be feasible to establish an SCGE model at a more detailed spatial level than that of the English regions.

5.2.73   Although it might be difficult to make a strong case for developing an SCGE model of England for the sole purpose of transport analysis, such an approach might have a role if developments in regional economic policy were to result in better data on sub-national, regional and local economic activity. The development of a demonstration model is of interest as a means of illustrating the complex interactions, many of which are omitted from the other approaches covered in this review.

5.3   Conclusions and Recommendations for Further Research

5.3.1   The framework used for estimating the impacts of a transport project on economic welfare through cost benefit analysis has been well established in England for more than 40 years. Cost benefit analysis is used to inform transport decision making in England and in most other countries that have a tradition of evidence-based policies. While the methods have been refined and extended, the basic principles are generally accepted and the development of the technique has been incremental.

5.3.2   This is a marked contrast to the approaches we have reviewed for estimating the sub-national, regional and local impacts of a scheme on GVA, employment, or similar measures of the performance of the real economy. A range of different approaches exists, some addressing the specific impacts of transport in an urban economy, while others are not restricted to a specific area type. The behaviour of transport users and of firms represented in the approaches we have reviewed differs, with some focused on the change in effective density, a variable which in some models causes and in other models is correlated with an increase in productivity, while others are based on the responses of firms and households to

both transport cost changes and the changes in land rentals and other prices that follow from the transport cost changes.

5.3.3   The range of approaches developed for estimating sub-national, regional and local economy impacts suggests that there is no agreement on an ideal approach.   In our view the strengths of, for example, LUTI and SCGE models may well lie in addressing different problems. Almost all methods reviewed have particular strengths in certain areas but they also have weaknesses which would need to be addressed.

5.3.4   For example, the further development of Spatial Computable General Equilibrium (SCGE) methods, could be supported on the grounds that this provides estimates of the impact of the scheme throughout the whole economy as firms, consumers and government respond to the whole range of changes in prices and quantities of goods, services and land availability and in the location of producers and households following the implementation of a transport scheme or policy intervention.   Comprehensive though this approach might be (and most if not all such models are still under development and at a very early stage in the process in the case of the one English model based on this approach), it does not recognise that economic growth can be endogenous and caused by changes in the structure of the economy, rather than exogenous as assumed in the SCGE models.   There is therefore no one ideal spatial economic impact model which might serve to guide the future direction of research and development.

5.3.5   The economic impact models that have been developed for use in countries such as the Netherlands, certain US states and the EU have been supported by substantial research funding.   Most of the models we have reviewed have been developed and funded by consultants who see a commercial case for providing clients with access to such models.   The data that such models would ideally need is often extensive and not available at the appropriate level of spatial detail and therefore assumptions and approximations have been required in order to provide an operational tool.   Given this background, it is not surprising that we have been able to identify certain shortcomings in these approaches – indeed it is remarkable that these models, in some cases, have been developed to the levels that they have reached largely without the involvement of the DfT or other government departments.

5.3.6   None of the models described take any account of the funding requirements for the scheme. This approach might be acceptable in the circumstances in which a budget is allocated to the DfT by Treasury, and the economic case examines whether the project represents value for money.   But where a local contribution to a scheme is a condition of it being approved, there is a strong case for including in the model some means of representing the local opportunity cost of this source of funds.

5.3.7   Most of the models we have reviewed are designed for estimating the impacts of urban schemes on local or intra-area levels.   Few of the methods have the capability, although they may have the potential, for analysing the impacts of improving connectivity between cities. If transport policy moves towards a stronger focus on inter-urban schemes, the absence of any suitable method for estimating the 'two-way road' impacts of such a policy on the 'real economy' is likely to be a significant gap to address in transport analysis.

5.3.8   Wage equation models have been developed to estimate the economic impacts of schemes that serve conurbations and in some versions have made good progress in illustrating the effect that transport schemes could have in contributing to higher productivity.   The KMPG model developed for Greengauge 21 is the only one we have identified and examined that

provides an estimate of the impact of connectivity on employment densities and the impact for attracting more jobs from elsewhere into the conurbation.

5.3.9   None of the wage equation models that we have seen help to identify the zones from which either the more productive workers have come, effectively switching jobs with the less productive former conurbation workers, or, in the case of the KMPG model, the zones which provide the additional conurbation employees. With density based wage equation models other than the KMPG approach, a further step is required to estimate the extent of any increase in employment density attributable to the scheme. The Volterra/Buchanan version of the WebTAG based partial equilibrium approach, which is of the wage equation school, provides one means of estimating this effect.

5.3.10   SCGE models are not at present at a stage of development for use in anything more than as a demonstration of their potential, and the lack of appropriate regional trade data suggests that this situation is unlikely to change soon.

5.3.11   The EALI approach provides information that Transport Scotland has required. It has been applied to relatively small rural schemes and also to much larger strategic schemes such as the planned new Forth crossing and city bypasses. The Regeneration Impacts guidance provided by DfT in WebTAG also already provides a useful framework. The current guidance would need to be developed if there is a requirement for it to be able to, for example, estimate impacts in other areas outside of the identified regeneration area, and therefore the net national effect. The evidence for the impacts of changes in accessibility, in terms of jobs supported and created, is also in need of further development, if this approach is to provide more robust information. Nevertheless, the EALI and Regeneration Impacts frameworks do already provide a basis for a potential method that could be used in a consistent way.

5.3.12   The survey-based approach has worked well in identifying the scope for investment as a result of removing a transport constraint on specific sites intended for development. It does not attempt to provide an overview of the full local economic impact, generally focusing on the additional jobs rather than estimating the costs of the overall package, including the costs of developing the site and establishing the factories or other buildings which provide those jobs. It is not likely to be suitable for other applications.

5.3.13   LUTI models, including as a variant the UDM, have a number of strengths which have been outlined in the previous chapter. But the use of a LUTI model remains the exception and the fact that the module of the model which addresses the impact of a scheme on the local economy is still under development suggests that this approach is not appropriate if the only aim of using such a model was to estimate this impact.

5.3.14   The overall conclusions that can be drawn from this review are:

- There is currently no suitable method in its current form that could be widely used to meet all requirements for accurately estimating sub-national, regional and local economy impacts;

- All of the existing methods have their strengths and weaknesses. It is not clear that the weaknesses can easily be overcome, and the results generated from use of these methods should be viewed in the context of relevant uses and limitations; and

- Some methods are better suited to addressing specific questions than others, and are capable of providing information that can be useful for understanding sub-national,

regional and local economy impacts. The choice of the appropriate approach to use will depend to some extent on the specific question that needs to be considered.

5.3.15   As explained in the previous section, this review concludes that there is currently no ideal method which could consistently be applied across all scheme types to deliver all requirements for estimating the sub-national, regional and local economy impacts of transport proposals. All have certain strengths, but many have particular significant weaknesses which limit their application in their current state.

5.3.16   Some methods are better suited to addressing specific questions than others. Indeed, many have been specifically designed to address a particular need. The choice of the appropriate model to use will therefore depend to some extent on the specific question that needs to be considered. For example, it is certainly possible that a methodology could be developed using the existing frameworks recommended in DfT's guidance on Regeneration Impacts (WebTAG Unit 3.5.8) and Transport Scotland's Economic Activity and Location Impact assessment. While these may have weaknesses, they could be developed to be 'fit for purpose' guidance that could be applied on a consistent basis for estimating the impact of relatively small schemes.

5.3.17   However, if the methods will be required to examine the impacts of large, and particularly inter-urban, transport schemes then a more sophisticated approach may be required. For schemes of this type, all of the methods considered have their inherent weaknesses. It is possible however that these methods could be further developed.

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Appendix A – Appraisal Criteria Working Paper

D3 – Working Paper

Project:	DfT Local Economic Impacts
Subject:	Proposed Appraisal Criteria
Note Number:	Version: 4.0 FINAL
Author(s):	Paul McCartney
Reviewer(s):	Katie Hall, Steve Lowe
Date:	1 May 2013

Proposed Criteria

The purpose of these assessment criteria is to create a framework for assessing the strengths and weaknesses of the different approaches to appraising the economic impacts of transport interventions at sub-national, regional and local scales. Each criterion helps to identify the features of a good method, and to identify the strengths and weaknesses of each method.

The criteria headings are set out below in red, with sub-criteria as bullet points within some criteria. Following each criteria and sub-criteria is an accompanying explanation and questions that should be addressed in assessing specific methods against the criteria and sub-criteria.

Criteria: Consistency with Robust Economic Theory

Explanation

It is clear that the various approaches currently being used to assess the sub-national, regional or local impacts of a transport intervention are based on different fundamental economic relationships linking transport investment and impacts on economic activity.

A good method will provide strong grounds, in terms of the underlying economic theory and principles that form the framework for the method, to support the case that a transport intervention will lead to an increase in economic activity.

It will, for example, demonstrate how the transport improvement is expected to feed through to higher levels of economic activity / GDP e.g. reduction in input costs, increases in output and / or employment? These relationships should be adequately explained in the documentation as should any further initiatives necessary to deliver the increase in economic activity.

Questions for assessment of criteria

- Is there a clear explanation of the economic theory and principles that form the framework for the method?

- Are the relationships via which the transport intervention is expected to feed through to a change in economic activity consistent with robust economic theories?

Criteria: Empirical Evidence

Explanation

Evidence should be presented to support the impact of the transport improvement on the local economy. However, the literature to date suggests that the evidence to support the claimed direct linkages between transport investment and impacts on economic activity is not conclusive.

A good method will therefore provide evidence to support the claimed impacts of the scheme and also indicate the robustness and/or uncertainties of the evidence.

It should also explain why the evidence is relevant to the study / analysis e.g. the same mode, the same local labour market conditions apply, similar area characteristics and sectoral mix, similar scale etc.

A particular source of uncertainty can be the direction of causality. Many factors – for example, transport connectivity and employment density – are closely correlated and it is difficult to separate the cause and effect. The method should therefore recognise where this is a difficulty and provide supporting evidence to distinguish between cause and effect in its assumed economic relationships.

Questions for assessment of criteria

- Does the method provide a clear and appropriate description of the empirical evidence that supports the claimed impacts, and also indicate the robustness of, and uncertainties associated with, the evidence?

- Does the method provide a robust justification of why the evidence is relevant for specific types of study / analysis, and also explain if there are limitations associated with its use?

- Does the method provide robust evidence for the claimed direction of causality between cause and effect of any claimed economic relationships e.g. the transport intervention and change in economic outcomes?

- Are sensitivity tests provided that show the impact of changes in key assumptions and empirical estimates that are used?

Sub- Criteria: Assessment of Land Use and Availability of Land

Explanation

Conventional transport models generally assume a fixed land use and that transport improvements accrue to existing businesses only by increasing productivity through, for example, reducing travel costs and through benefits from agglomeration. Local economic impact models however can be based on the assumption of flexible land use and business/workforce relocation (to allow a move to more productive jobs and an increase in total

employment in the study area). It is important to understand these assumptions and their robustness as many of the benefits claimed are due to entrants into the local labour market leading to increased productivity and growth.

The method should also be clear whether assumptions about changes in land use have implications for the estimates of demand derived from the transport model if this is based on a different land use assumption.

Questions for assessment of sub-criteria

- Does the method provide robust explanation of why land use is assumed to be fixed, flexible, or flexible with constraints?

- Does the method provide robust theoretical and empirical evidence for the claimed relationship between the transport intervention and the impact on the location of businesses and workers?

- If the method assumes flexible land use, are estimates of changes in land use taken into account in the estimates of transport demand?

- Are the assumptions about land use consistent with the relevant land use planning frameworks?

Sub-criteria: Labour Supply

Explanation

It is important that a method or model used can clearly explain the impact and assumptions on the supply of labour. Presenting a transparent account of the impacts on the labour supply will be crucial to the credibility of the method and results. For example, in estimating job / employment impacts, what assumptions are made about the supply of labour and how it contributes to higher levels of activity?

The method should be clear whether the results are dependent on a supply of labour resource e.g. unemployed labour, and provide the evidence to demonstrate that this exists in the form assumed e.g. skilled or unskilled or whether an increases in the labour force are a result of relocation of workers from outside the study area and, if so, whether from other parts of the UK or abroad.

- The model should also be clear about, if there is claimed additional output per person, what causes the increased output? Evidence should be provided to support this effect and that it is a cause of the transport improvement. The method should explain whether the increase in output is from 'real' agglomeration effects as measured through wider impacts guidance i.e. within the existing sectoral mix, or is the increase in output generated by productivity impacts brought about by a change in the sectoral mix with low value jobs shifting out of the study area and higher value ones moving in.

A good method should therefore be clear whether the method assumes relocation of labour and / or business under the do-something option and where the labour supply has come.

Questions for assessment of sub-criteria

- Does the method provide a robust case, consistent with theory and empirical evidence, of how the transport intervention is assumed to affect labour supply in the study area and how this contributes to higher levels of economic activity?

Sub-criteria: Elasticities

Explanation

A number of the approaches for calculating local economic impacts, and the results generated, are dependent on robust estimates of labour supply elasticities and the response of the workforce to changes in wages. A number also include elasticities of productivity with respect to effective density.

It should also be made clear whether the elasticities used are evidence-based or whether there are possible limitations e.g. are the elasticities applicable to the occupations and/or geographic area that contribute to the increases in economic activity, and if not what are the implications?

Information should be provided about the sensitivity of the estimated outcomes to uncertainties around the elasticity values and the extent of these uncertainties.

Questions for assessment of sub-criteria

- If the method is dependent upon elasticities, does the method explain the evidence upon which the elasticities are based?

- Is the supporting evidence for these elasticities robustly based on empirical evidence and suitable for the specific use in which they are being applied?

- Does the method clearly explain the uncertainties around the elasticity values, the extent of these uncertainties, and the impact that these uncertainties could have on estimates that are generated from the method of the economic activity impacts of a transport intervention?

Criteria: Dependency on other factors

Explanation

It is important to understand whether the impacts predicted by the models are dependent on other factors occurring / complementing the transport investment. SACTRA concluded that additional, non-transport investment is generally required to deliver economic impacts. In addition, Eddington concluded that, in itself, transport investment may not create additional economic activity i.e. it is conditional on other factors, such as local market circumstances and labour market conditions.

The method should therefore clearly explain whether the impacts on economic activity are dependent on the transport investment alone, or whether it is assumed to act as a catalyst for a number of other structural changes and market conditions in the local economy, e.g. flexible labour market, under-employment of land and capital, business capital, housing, business premises etc, and whether such assumptions are credibly supported by evidence.

Also, it will be important that the non-transport factors that are needed to generate the impacts are made explicit, including their own benefits, costs and externalities. In addition, evidence

should be provided to show that the non-transport impacts are likely to materialise. For example, by specifying any constraints on planning permission that might influence the level and location of development.

If the method is dependent on other, non-transport factors materialising, the costs associated with these impacts should be included. In addition, these costs should include the impact of any local contribution to the scheme.

It should also be clear whether method takes account of opportunity costs.

Questions for assessment of criteria

- Does the method explain whether the impacts estimated are dependent on other factors occurring / complementing the transport investment?

- Are the non-transport factors that are needed to generate the impacts made explicit, including estimates of their own benefits and costs included externalities?

- Is evidence provided that the non-transport factors are likely to materialise?

Criteria: Counterfactual / Do-minimum

Explanation

Any economic impact assessment implicitly or explicitly involves the comparison of a Test Case with a Do Minimum or Reference Case. Understanding this counterfactual is crucial to the assertion of whether an intervention is likely to have the estimated effect, particularly if there are other proposals or schemes included in the Do Minimum which could influence the quantum of impacts of the proposal under consideration. It is important therefore that model users provide a clear explanation of a counterfactual so that there is transparency around the assumptions made with regard to the scenario where the proposed scheme is not introduced.

It will also be important to understand whether the Do Minimum is comparable with the 'do-minimum' of the cost benefit analysis transport appraisal.

A good method should therefore explain details of the counterfactual, particularly whether it is consistent with the do-minimum assumed in the CBA.

Questions for assessment of criteria

- Does the method provide a clear explanation of the counterfactual so that there is transparency around the assumptions made with regard to the scenario where the proposed scheme is not introduced?

Criteria: Data Use and Availability

Explanation

Many of the methods / models are highly dependent on specific data requirements, particularly at the local or regional level e.g. local levels of labour productivity by sector. However, in many cases this data is not readily available, and it will therefore be important to understand these requirements and limitations of the approach if the data is not available.

The extent to which the data which is best suited to the analysis has been used should be made clear, as should the reliance placed on data which has been used but is less than ideal, for example because it covers a wider or different geographical area on the grounds that the ideal data is not available. It should also explain whether there any limitations or weaknesses with the data used e.g. has proxy data been used and, if so, whether it has possible limitations.

Questions for assessment of criteria

- Does the method explain why the data that is used is best suited to the analysis?

- Does the method explain limitations or weaknesses associated with the data that is used, and identify how these could affect the analysis?

- Is the data required for application of the method freely and readily available for the study area under consideration?

Criteria: Uses and Limitations of the Method

Explanation

It is important to understand the limitations associated with the use of a particular method e.g. are there theoretical or empirical limitations with specific applications of the approach the approach and are the assumptions of the method not suitable for use for specific applications.

Questions for assessment of criteria

- Are the key limitations associated with applying the method clearly explained?

- Are the assumptions associated with the approach clearly documented so that they are open to considering the suitability of the method for specific applications?

Criteria: Calibration and Validation

Explanation

A potential key issue for determining the suitability and robustness of the methods will be the calibration and validation of the models used.

The terms 'calibration' and 'validation' are more generally associated with 'models' as opposed to 'approaches'. In a transport model context these terms are well understood in terms of (a) the models representing the present day observed situation, and (b) the models responses to certain changes in inputs (e.g. a fuel price increase) being within accepted and established ranges.

In this case though, the modelled relationships are not well understood or accepted. In addition the complexity involved (i.e. the myriad of factors which affect the real economy) means that there is very little scope to 'validate' models against observed outcomes over time. For example, it is not possible to validate a land use model in the same way as a transport model. These models are built up from a large number of relationships which themselves have been derived via empirical or theoretical evidence.

Instead this therefore comes back to the strength of the evidence used to support the key relationships being modelled. For example, the derivation of elasticities and the evidence produced to support these values is a key issue.

Questions for assessment of criteria

- Is the evidence used to support the key relationships that are included in the method consistent with robust theory and empirical evidence, such as the evidence used for the derivation of elasticities?

Criteria: Compatibility with Transport Model and with Transport Appraisal

Explanation

It is important that assumptions in the method used to estimate the local economic impacts are consistent with the main transport modelling and transport appraisal assumptions. A good method should be clear that there are no contradictions between the two sets of assumptions e.g. are these the same as have been used in estimating the relationship between transport costs and output (or employment) from which the employment or productivity elasticities have been derived? Are all mode costs combined or analysed separately?

Questions for assessment of criteria

- Are the assumptions in the method for estimating local economic impacts consistent with the main transport appraisal assumptions? If not, are any deviations in the assumptions soundly justified?

Criteria: Metrics

Explanation

The different methods may present the outputs using different metrics. For example, some are presented in changes to GDP and / or GVA and / or employment. It may be that DfT or the decision makers for whom the analysis is being undertaken want the results to be presented using a particular metric, perhaps to allow comparison across projects.

The output metrics used should be appropriate and meaningful in terms of meeting requirements for informing decision making.

Questions for assessment of criteria

- Are the metrics reported by the method useful and appropriate for informing the relevant decision makers?

Criteria: Winners and Losers and Spatial Distribution

Explanation

This is a key criterion in the assessment, as many economic impact assessments focus solely on the immediate area of impact, without differentiating between newly generated economic activity and activity which has been redistributed from outside of the study area. Results should preferably show the economic impact at the national level as well as the local / regional / sub-national level.

The introduction of new or improved transport links can clearly have more than one impact between the areas they are connecting. For example, both areas could see improvements, or at least net improvements as different sectors within each area are affected positively or negatively. Alternatively, one area could gain at the expense of the other. Indeed, it is possible that the area intended to benefit could see a negative impact on economic activity under certain circumstances e.g. inefficient industry and labour market being exposed to outside competition – the so called two-way road effect.

While there are no hard and fast rules on which areas would benefit or lose in response to a transport intervention, it is important to assess how the model takes account of the impacts outside the study area and explain how factors such as economic activity, labour market performance etc are affected outside the study area (if at all). Again the evidence base underlying this will be important.

Implicit in this is the importance that the spatial area is covered by the model e.g. local or regional and whether it accounts for impacts beyond the study area in any way. The approach should make clear how the redistribution of economic activity and of households is estimated and modelled.

In addition, the method should explain how the displacement of the activities that move to the places benefitting from transport investment has been estimated and modelled. The method should also demonstrate to what extent displacement takes place *within* the study area and the impacts of this and whether the regions outside the study area from which economic activity is displaced identified.

Finally, the models tend to deal with economic impacts (costs and benefits) that materialise over different time periods. The model needs to compare impacts of a particular intervention over different timescales, including the discounting which is applied to ensure like for like comparisons. A consistent approach is therefore required to ensure impacts associated with a particular scheme and its performance can be compared on a like-for-like basis.

Questions for assessment of criteria

- Does the method take account of, and include estimates for, the impact of the transport proposal on other geographical areas outside the area that is under consideration?

- Does the method have a robust approach to estimating additionality and displacement of economic activity?

- Does the method apply an appropriate approach to discounting impacts that are generated in future years?

Criteria: Non-economic Impacts

Does the economic or any other analysis identify other impacts such as the environment and non-work / social, which might have an impact on the location of households and employment? What account has been taken of the possible indirect effects on economic output, and is robust evidence provided and explained of these impacts?

Criteria: Implementability

Is it straightforward / practical to implement the method? Can it be adapted to be easily implemented to the specific proposal under consideration? Does it require a specific skill base? Can it be used more generally or are there issues such as intellectual property rights and / or software licensing? What is the preparation time to set up models and their run times? Is there a high risk of error because of complexity?

Questions for assessment of criteria

- Does the method include clear and accurate guidance on its implementation and any limitations with its use that users should be aware of?

Future Development

The following three topics are not necessarily criteria for assessing the methods; they are issues for consideration in understanding the future development of the methods.

Transferability

For consistency and to allow like-for-like comparisons across schemes, it would be useful to have a method that is suited to all scheme types and not lead to bias under particular uses. It is important to therefore understand whether a particular method is transferable e.g. between transport modes or measures, areas, over time, for different scenarios and with different policy objectives. What would be needed to apply a method used in one conurbation to a different location or larger or smaller area, or between different modes of transport?

Proportionality

In line with existing DfT WebTAG guidance, it is important to understand whether the methods could be adapted for use in a proportional way e.g. are they flexible enough to be used for schemes with relatively small impacts?

Future Potential of Each Approach

While a particular method may not necessarily be robust in its current design, it would be useful to understand to what extent it could be amended and / or improved so that it could be used in a way which would meet the requirements for scheme assessment. In addition, there may be new data or research in the pipeline which could increase the robustness of the approach.

Questions to consider

- Does the method include explanation of the uses and contexts in which can be validly applied, and identify any uses and contexts for which it is currently not suitable?

Appendix B– Assessments of Methods Against Criteria

Appendix B is provided in a separate document published alongside this report.

MVA Consultancy provides advice on transport, to central, regional and local government, agencies, developers, operators and financiers.

A diverse group of results-oriented people, we are part of a strong team of over 500 professionals worldwide. Through customer research, strategy development, transport modelling, business planning and operational implementation we create solutions that work for real people in the real world. For more information visit www.mvaconsultancy.com

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