Institution: Imperial College London

Unit of Assessment: 14-Civil and Construction Engineering

Title of case study: 6. Economic impacts of transport investments for appraisal and decision making

1. Summary of the impact

This case study describes impacts on the professional practice of transport appraisal, and on investment planning at national and local levels, arising from an approach developed over the period 2005-2013 to estimate the Wider Economic Impacts (WEIs) of transport investments. The research instigated an important reform of the UK approach to Cost Benefit Analysis (CBA) and provided key empirical evidence that has been formally incorporated in the UK Department for Transport (DfT) web based CBA guidance (WebTAG) since 2009. Governments and public authorities throughout the world subsequently adopted the models and techniques proposed as decision support tools for infrastructure investment and planning. Since 2007 Imperial staff and their industrial collaborators have applied the approach to approximately 150 Billion US Dollars of international transport investment, and its use and impact are now widespread globally. It is now a standard textbook approach for assessing the WEIs of transport investment. Recent applications of the approach in the UK include the official economic evaluations of CrossRail (2010) and High Speed 2 (2010, 2012).

2. Underpinning research

The underpinning research developed a robust modelling framework to assess the impacts of accessibility on the real economy and showed how key parameters from these models can be used to improve techniques for investment appraisal.

Economic appraisal methodology, based principally on CBA, was established in the early 1960s and has changed little over the last 50 years. While CBA has proven to be a useful tool for comparative assessment of transport investments, it has long been recognised that the benefits measured by the conventional approach, based almost exclusively on travel time savings, are incomplete. In particular non-trivial impacts on the productivity of the real economy are not evaluated because these were considered elusive and beyond the scope of existing empirical models. This represents a substantial gap in knowledge because economic impacts typically form a principal consideration in transport investment decisions.

This gap in knowledge provided the impetus for research into the Wider Economic Impacts (WEIs) of transport investments. Statistical estimation of the economic effects of transport infrastructure is challenging because experimental evidence is not available and investments are typically not assigned randomly. Consequently, simple comparisons of average outcomes between groups that received investment and groups that did not, will not in general reveal a causal treatment effect. Instead, a detailed modelling framework has to be established which can adjust for differences between groups in estimating robust treatment effects. Furthermore, the framework has to be capable of allowing meaningful comparison across multiple types of investment of different scales and purposes.

Research led by Professor Dan Graham between 2005 and 2013 developed a series of models to provide empirical evidence on the impact of changes in accessibility on economic productivity and growth. Key challenges addressed in the statistical modelling work included estimating treatment effects in the presence of confounding, reverse causality and measurement error. A methodology was developed and implemented using extensive data on firms across all sectors of the UK economy and designed such that the resulting empirical estimates of impacts on the real economy were additional to the impacts measured by conventional appraisal. This allowed the evidence to be incorporated directly within an extended CBA to capture a wider range of benefits.

The research was led by Professor Dan Graham, a Senior Research Associate, Reader and then Professor in CTS between 2005 and 2013.

3. References to the research (* References that best indicate quality of underpinning research)

[1] Graham D.J. (2005) *Wider economic benefits of transport improvements: Link between agglomeration and productivity*, London, Department for Transport. Available on request.

[2] Graham DJ (2006) *Investigating the link between agglomeration and productivity for UK industries* (research appendix to the Eddington Report), London, HM Treasury. http://www.transportworks.org/sites/default/files/assets/evidence_base_documents/Investigating%20the%20link%20between%20productivity%20and%20agglomeration.pdf Also available here

*[3] Graham DJ (2007) 'Agglomeration, productivity and transport investment' *Journal of Transport Economics and Policy*, **41**(3), pp 317-343. http://www.jstor.org/stable/20054024

[4] Melo P., Graham D.J. and Noland R.B. (2009) 'A meta-analysis of estimates of urban agglomeration economies', *Regional Science and Urban Economics*, **39**(3), pp 332-342, doi: http://dx.doi.org/10.1016/j.regsciurbeco.2008.12.002

[5] Graham D.J., Gibbons S. and Martin R. (2010) The spatial decay of agglomeration economies: estimates for use in transport appraisal*, London, DfT. http://assets.dft.gov.uk/publications/the-spatial-decay-of-agglomeration-economies-estimates-for-use-in-transport-appraisal/agglomerationreport.pdf Also available here.

* [6] Mare D and Graham DJ (2013) 'Agglomeration elasticities and firm heterogeneity', *Journal of Urban Economics* **75** pp 44-56, doi:10.1016/j.jue.2012.12.002

Evidence of the quality of the research

The research has been published in the leading academic journals and is widely cited in the literature. Regional Science and Urban Economics (RSUE) and the Journal of Urban Economics (JUE) are two premier journals in the field. Paper [4] is the most cited article in RSUE since 2008 and paper [6] is currently the 11th most downloaded article in JUE. The modelling approach proposed in the research now commonly features in modern textbooks on transport economics and CBA (e.g. *Handbook of Transport Economics*, 2011, Edward Elgar). Keynote talks on this subject have been presented at several high profile international meetings, including major conferences at the World Bank (2005), the US DoT (2010), the OECD (2007, 2011), the UK Government Economic Service Annual Conference (2008), the Universities Transport Research Consortia of New York and New Jersey (2012), and at the International Transport Economists Conference (2009), one of the most prestigious events in the field. The research has attracted considerable research council funding (ESRC 2010-2012) as well as from the DfT, TfL, New Zealand Transport Authority, the US DoT, and High Speed 2.

In addition to the normal mechanisms for academic peer review, the UK DfT subjected the original research to detailed scrutiny through requests for written critiques of the work from leading world experts and through a series of workshops and conference to elicit professional and academic opinion. Through these exercises the DfT received highly favourable comments and subsequently adopted the Imperial approach as the preferred method for transport CBA.

4. Details of the impact

Graham's academic research undertaken at Imperial in 2001 provided an initial general approach for measuring the effects of accessibility on productivity. In 2005 the UK DfT commissioned him to develop this work to devise a specific approach to WEI estimation that would produce empirical results compatible with existing methods of appraisal [1,3,5]. Between 2005 and 2008 the DfT disseminated the results of the Imperial research in a series of high-profile conferences, seminars and workshops aimed at informing civil servants and professional analysts about these new techniques. These included the following events

- 'Wider Benefits of Transport Investment' given to the Office of the Deputy Prime Minister / Department for Transport seminar (November 2005)
- 'Agglomeration and Transport' given to HM Treasury (Eddington Group) (July 2006)
- 'Transport and agglomeration', OECD Round Table on Macro-, Meso- and Micro-Infrastructure Planning and Assessment Tools, Boston (October 2007)
- 'Transport and productivity', DfT Conference on the Eddington Report and Transport Policy, London (April 2007)
- 'Transport investment and urban productivity', DfT Eddington Analytical Seminar, London (May 2007)
- 'Measuring wider economic benefits of transport', UK Government Economic Service Annual Meeting, Nottingham (July 2008)
- 'Cost Benefits Analysis', US Department of Transport Benefit Costs Analysis Conference,

Washington DC (May 2010)

The research was also adopted by the UK Treasury who in 2006 funded (jointly with DfT) a research annex to their report on 'Transport's role in sustaining the UK's productivity and competitiveness' (The Eddington Report) [2]. The Eddington Report included detailed applications of the WEI approach to appraisal and argued that it provided a superior tool for decisions support than conventional CBA.

The significance of the research on WEIs is that it has led to an important reform of CBA for project appraisal of transport schemes, and consequently has influenced investment planning at national and local levels [A-E]. Following publication of this work the DfT subsequently undertook a major revision of their CBA methodology (2007-2009) based on Imperial's approach for the assessment of WEIs and in 2009 formally incorporated Graham's estimates in the DfT web based CBA guidance (WebTAG) (see http://www.dft.gov.uk/webtag/documents/expert/pdf/U3_5_14-wider-impacts120723.pdf) [A,B,C]. Interest in WEIs spread rapidly and has been taken up by national Governments and public authorities throughout the world as a decision support tool. It is now used routinely by the transport modelling profession as the standard approach for WEI assessment.

Within the UK, high-profile examples of the direct application of the Imperial approach (with economic value indicated) include CrossRail (2010) (£16bn) [F], High Speed 2 (2010, 2012) (£50bn) [G], Manchester Rail Hub (2009) (£530m), and the Leeds city-region transport strategy (2009-2012) (£4bn). Indications are that it will be used to assess the case for CrossRail 2.

Following formal adoption of the WEI approach in the UK interest spread throughout the world. Initial international applications took place in Australia (2011) [J], New Zealand (2010, 2011) [H, I], and the USA (2009). We have been active in leading the spread of our approach worldwide. The table below summarises the projects in which Imperial or its industrial partners have been directly involved since 2009 and shows that almost 150 billion US Dollars of international investment has been appraised using the Imperial approach.

Project	***Country***	***Value of project (US$ million)***
CrossRail	UK	26,662
High Speed 2	UK	76,923
Manchester Hub Phase 1	UK	833
A11 extension	UK	160
A120 extension	UK	1,140
A5-M1 Link Road	UK	208
Leeds City Region Transport Strategy	UK	6,289
Cross River Rail, Brisbane	AUS	5,385
Auckland CBD Rail Loop	NZ	1,250
Parramatta Epping Rail Link	AUS	2,564
East of England Transport Economic Evidence Study	UK	1,629
UAE Rail Network	UAE	11,434
A46 Widening	UK	583
Heathrow AirTrack	UK	1,058
New Zealand Roads of National Significance	NZ	3,824
Porto-Lisbon High Speed Rail	PRT	6,361
Tees Valley Metro	UK	293
Total		**146,596**

Recent research for the DfT carried out by the University of Leeds shows that the approach has now been formally adopted in the Netherlands, Sweden, New Zealand, Israel and Australia and is currently being implemented by the World Bank and the United Nations [K]. Furthermore, recent desktop research of impacts finds much more extensive use of concepts and calculations derived from the research. The fundamental contribution of the work lies in developing an empirical approach to capture the productivity effects of changes in the transport network. This is done by estimating a set of parameters that will typically differ by country, and possibly by regions of countries, and there is therefore a very large scale of on-going work to roll the approach out in different countries.

The benefits of the research accrue to many different groups in society. It offers Governments improved information upon which to make decisions about transport investments, and in so doing, can support improvements in economic growth and productivity for regions and nations. It provides the transport profession with more robust ways of modelling the impacts of investment on the economy, and it advances the scope and influence of the transport modelling discipline. It allows interest groups and societal organisation access to more reliable information about the impacts of infrastructure proposals that affect them. Finally, it aids the coordination and planning of major infrastructure projects and helps in prioritising transport spending to achieve better outcomes for society in terms of value for money, economic growth and productivity.

5. Sources to corroborate the impact

[A] Letter of corroboration from former Chief Economist for Transport Appraisal, Department for Transport. To corroborate the impact on transport investment and policy such as Crossrail, Manchester Rail Hub and High Speed 2.

[B] Letter of corroboration from former Head of Transport Analysis and Review, Department for Transport confirming the inclusion by the DfT of Dr Graham's appraisal methodology to incorporate the wider economic benefits within its investment appraisal guidance (WebTAG)

[C] Letter of corroboration from Economic Advisor, Transport Appraisal and Strategic Modelling Division, Department for Transport. This letter confirms the WEI (wider economic benefits) approach been used in DfT's assessment of the value for money of a number of major transport schemes, including high profile schemes such as Crossrail, and High Speed 2, and also for several smaller schemes proposed by local transport authorities.

[D] Letter of corroboration from Director of Customer Experience at Transport for London (TfL). Previously in charge of major projects to corroborate that the research was fundamental to making the case for Crossrail and that the research also helped Transport for London reorient its entire approach to investment.

[E] Letter of corroboration from Principle Advisor for Economics, Planning and Infrastructure, New Zealand Transport Authority. To corroborate that the research has been used extensively in assessing the wider economic impacts of the Roads of National Significance (RoNS) programme in New Zealand and for appraising other significant projects.

[F] Crossrail Business Case, 2010, (Mayor of London, DfT, CrossRail and TfL) Available at http://assets.dft.gov.uk/publications/pgr-rail-pi-crossrail-businesscase-pdf/summaryreport.pdf Also available here

[G] Economic Case for HS2: Updated appraisal of transport user benefits and wider economic benefits, 2012, (DfT) Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/3650/hs2-economic-case-appraisal-update.pdf Also available here.

[H] Wider economic impacts of transport investments in New Zealand, 2011, (New Zealand Transport Authority) Available at http://www.nzta.govt.nz/resources/research/reports/448/docs/448.pdf Also available here.

[I] Auckland CBD Rail - assessing wider economic benefits, 2011, (New Zealand Transport Authority) Available on request.

[J] Cross River Rail Brisbane, 2011, (Queensland Department of Transport and Main Roads) Available on request

[K] Mackie, P.J. and Worsley, T. (2013) International Comparisons of Transport Appraisal Practice: Overview Report, Report to UK Department for Transport (pp 9, 26) Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/209530/final-overview-report.pdf Also available here.