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Project Appraisal Guidelines Unit 6.9 - Wider Impacts

PE-PAG-02028
December 2023

PE Planning & Evaluation

Technical

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Unit updated to incorporate new Irish parameters relating to agglomeration impacts of transport projects and guidance on the use of a TII tool to calculate these impacts for national road projects.

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Unit updated to incorporate updated Irish parameters to be used in the TII Agglomeration tool as well as formatting updates made to the Agglomeration tool guidance notes in order to increase user accessibility and clarity.

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1. Introduction

Cost Benefit Analysis (CBA) forms one element of the appraisal process for transport infrastructure projects. CBA serves a number of functions at both the individual scheme level and when comparing different projects. Traditional methods of CBA for transport infrastructure projects focus on user and provider impacts.

"Wider Impacts' is the term given to the welfare impacts of transport investments that are additional to transport user and provider impacts. These Wider Impacts include changes in productivity, output and employment as a result of an investment in transport infrastructure. These benefits occur because the transport investment addresses a market failure and allows the economy to function more effectively.

A number of market failures relevant to a transport appraisal can be identified. Transport investments can address these failures, and so give rise to Wider Impacts. These market failures are:

- **Agglomeration Economies**: When firms are located close together their productivity increases. In economic terms this is an "externality", that is, if a firm moves closer to other firms it will not capture all of the benefits of the resulting increase in productivity. An outside intervention such as an investment in transport infrastructure can, therefore, realise benefits by increasing agglomeration
- **Imperfect Competition**: Markets for goods and services are not perfectly competitive. Investments in transport can increase the intensity of competition on markets and so increase economic output and welfare
- **Knowledge Spill-over Effects**: These are another mechanism whereby firms clustering together will become more productive
- **Labour Market Imperfections**: Factors such as income tax, relatively immobile labour, sticky wages and labour market search costs mean that the labour market does not function like a theoretical competitive market. As a result any intervention that increases labour market participation can have net economic benefits

These market failures mean that a transport investment has a number of potential Wider Impacts. This Unit describes these Wider Impacts and makes practical recommendations for the treatment of them in Business Cases. The benefits discussed are:

- Employment impacts during construction
- Agglomeration impacts
- Increased competition in the economy
- Increased labour supply
- Tax benefits
- Inward investment impacts
- Re-organisation impacts
- Thin labour market impacts

The assessment of wider impacts in transport appraisal is relatively novel compared to the inclusion of the components of transport sector user benefit (e.g. travel time savings). This means that the data and methodologies for incorporating the wider impacts are in an early stage of development. Furthermore, for some of the impacts – particularly those that affect productivity, employment and earnings – a significant amount of data is required in a disaggregate form, and land use modelling may also eventually be required.

This guidance has therefore been written with this in mind. It blends the theoretically desirable with what is practically achievable and realistically relevant to an appraisal. It is expected that, typically, two types of wider impact would be estimated:

1. Increased output of firms and employment during construction
2. For large strategic schemes expected to affect the largest settlements in Ireland, agglomeration impacts may also be calculated

It is however noted that these will require a significant amount of bespoke data analysis. Furthermore, the inclusion of other Wider Impacts may also be relevant for these larger strategic schemes (e.g. tax benefits from increased labour supply, inward investment impacts, and increased competition in the economy impacts).

Project promoters are required to liaise with TII at the outset of the project through the Phase 0 Project/ Programme Outline Document (POD) deliverable to discuss the need and rationale for inclusion and assessment of Wider Impacts, and also to agree the proposed methodology to assess these potential impacts. TII will be able to provide guidance on the appropriate treatment of Wider Impacts and agree this treatment with the Department of Transport (DoT) and the Department of Public Expenditure, NDP Delivery and Reform (DPENDR).

2. Employment Impacts During Construction

2.1 Overview

Labour market failures such as immobile labour and 'sticky' wages can prevent the labour market adjusting to ensure that all those who wish to work at the market wage can find employment. As a consequence of these market failures, structural unemployment can exist. In areas of structural unemployment, job creation through construction has a positive welfare impact. This welfare benefit is additional to transport user benefits - provided unemployed workers are taken out of unemployment.

Shadow Pricing is the commonly used tool for dictating the welfare benefit of generating employment through construction. For example, a Shadow Price Factor of 0.8 applied to labour costs of construction means that the wage that would clear the labour market is 80% of the observed market wage, and hence creating employment through construction would have a welfare benefit of 20% of the wage costs.

In times of low unemployment, individual construction projects do not necessarily lead to job creation, hence the assumption of a welfare benefit from construction projects would not be valid. In such circumstances, the adoption of a shadow price factor of 1.0 is reasonable.

Current guidance, as set out in the DoT Transport Appraisal Framework (2023)[1], states that a shadow price factor for labour costs of 1.0 should be used in transport appraisals. If a Shadow Price of Labour value less than 1 is used, an explanation must be provided with objective evidence and with an emphasis on the sectoral labour market conditions.

[1] Department of Transport: Transport Appraisal Framework (2023) – Available at gov.ie - Transport Appraisal Framework (TAF) (www.gov.ie)

3. Agglomeration Impacts

3.1 Definition of Agglomeration

Agglomeration is a spatial effect, where firms derive a productivity benefit from locating closer to other firms. The existence of Agglomeration benefits, arising from the interaction of individuals and firms are important in the formation of clusters. These effects arise because firms derive productivity benefits from being close to one another and from locating in large labour markets. If transport investment brings firms closer together and closer to their workforce this may give rise to an increase in labour productivity above and beyond that which would be expected from the transport efficiency saving alone. Greater productivity in agglomerations arises from the fact that firms have access to larger product, input and labour markets. Knowledge and technology spill overs are important aspects that make agglomerations more productive.

3.1.1 Agglomeration Impacts

Agglomeration benefits are the product of:

- Labour market interactions
- Knowledge spill overs
- Strengthened linkages between intermediate and final good suppliers

Agglomeration economies are twofold, but represented by a single measure:

- Urbanisation
- Localisation

Urbanisation economies are externalities to firms and industries. These represent economies of scale arising from proximity to economic mass and are therefore productive advantages from locating in large population or employment centres. This allows firms to benefit from a concentration of population and associated benefits such as:

- Scale of local markets
- Formation of niches
- Proximity to intermediate inputs
- Proximity to output markets
- Availability of infrastructure
- Availability of Public Services

Localisation economies are external to firms, but internal to sectors. These represent economies arising from proximity to firms in the same industry. This allows firms to benefit from a concentration of firms in the form of:

- Increased specialisation of outputs
- Improved links to suppliers
- Improved links to labour markets, including improvements in job matching
- Increased exchange of knowledge

3.1.2 Agglomeration Effects

The UK Department for Transport (DfT) provides details in their online Web Transport Analysis Guidance (WebTAG) documentation on how transport investment can affect agglomeration through two distinct mechanisms:

1. **Static Clustering** - Transport investment can change the effective density of the cluster by allowing individuals and firms to more easily traverse the cluster, thereby facilitating interactions. This clustering impact occurs with no change to land-use
2. **Dynamic Clustering** - Transport investment can lead to changes in the physical density of a cluster by inducing a change in the level and/or location of economic activity (land-use change), thereby facilitating new/different interactions. Changes in the level and location of economic activity are related to labour supply and demand interactions

Static clustering assumes that increases in effective density will not influence the decision of firms and induce further co-location of firms in a specific sector. The locations of firms are therefore fixed.

Dynamic Clustering assumes that changes leading to increased density will induce additional co-location of firms. This is a second order effect of agglomeration. It is believed that these exist, however there is an insufficient evidence base or the required land-use models available to capture these effects.

Static Clustering is therefore the mechanism used to calculate agglomeration impacts for National Roads projects.

3.1.3 Displacement

Guidance on the treatment of displacement in relation to static clustering is provided in WebTAG. Displacement reflects the extent to which an increase in economic activity in one location is partially or fully offset by reductions elsewhere. The default assumption in UK transport appraisal is the full displacement of employment impacts resulting from transport investment. That is, unless there is evidence of a net national impact of a transport scheme on employment in the UK, it should be assumed that the net job impact is zero.

Under static clustering displacement is assumed to be zero; the local and national productivity impacts are equivalent if the local geographical area modelled covers the Generalised Transport Costs (GTC) for all affected trips. This is because static clustering involves no change in the location of economic activity, the productivity impact is solely the result of a change in GTC, which bring people effectively closer together.

Thus, displacement is not of concern in the calculation of agglomeration impacts for National Roads projects.

3.2 Agglomeration Metrics

3.2.1 Effective Density

The agglomeration metric known as 'Effective Density' provides a measure of the mass of economic activity across a modelled spatial area. This measure reflects the accessibility of firms and workers to each other, with the importance of one firm/worker to another declining as the distance between them increases.

Effective density is a measure of the accessibility of zone i to jobs in all destination zones. It depends on the employment level for all industry sectors in each destination zone j as well as the weighted average Generalised Cost of Travel between zones to the power of the distance decay parameter for the respective industry sector. The functional form of effective density is, therefore:

$$d_i^{S,k,f} = \sum_j \frac{E_i^{S,f}}{(G_{i,j}^{S,f})^{\alpha^k}}$$

Where –

$\boldsymbol{E_i^{S,f}}$ is the total number of jobs for all sectors in zone (i) for each scenario (S) for forecast year (f). Note that the number of jobs will be the same in both the Without Scheme (i.e. Do Minimum) and With Scheme (i.e. Do Something) scenarios.

$\boldsymbol{G_{i,j}^{S,f}}$ is the Generalised Cost of Travel from zone (i) to zone (j) in each scenario (S) for forecast year (f).

$\boldsymbol{\alpha^k}$ is the decay parameter for each sector (k). This is held constant irrespective of the forecast year

3.2.2 Sectoral Productivity Impact

Sectoral agglomeration impacts for each zone (i) and sector (k) are represented as $WI1_i^{k,f}$. They will vary depending on the forecast year**.** $WI1_i^{k,f}$ is estimated for each origin zone (i), being (k) the industrial sector and (f) the forecast year.

$$WI1_i^{k,f} = \left[\left(\frac{d_i^{DS,k,f}}{d_i^{DM,k,f}}\right)^{\rho^k} - 1\right] GVA_i^{DM,k,f}\ E_i^{DM,k,f}$$

Where –

$d_i^{DS,k,f}$, and $d_i^{DM,k,f}$ are the effective densities of origin zone (i) sector (k) in the Do Something and the Do Minimum scenarios respectively. This will vary depending on the forecast year (f) due to the change in the Generalised Cost of Travel over time associated with higher levels of traffic demand.

ρ^k is the elasticity of productivity with respect to effective density for sector (k). This is held constant irrespective of the forecast year.

$GVA_i^{DM,k,f}$ is the Gross Value Added (GVA) per worker of each area (i) sector (k) in the Do Minimum scenario. This will vary depending on the forecast year (f) in line with expected productivity growth.

$E_i^{DM,k,f}$ is the total number of jobs in sector (k), origin area (i) in the Do Minimum scenario. This will vary depending on the forecast year (f) in line with projected job growth.

3.2.3 Total Productivity Impact

Total productivity impacts for all sectors (k) and areas (i), to be calculated for a specific forecast year (in euros) is represented as $WI1^f$.

$$WI1^f = \sum_{i,k} WI1^{k,f}$$

3.3 Parameters and Economic Variables

The data required to undertake the calculation of agglomeration impacts for National Road projects are the following economic variables.

3.3.1 Elasticity of Productivity

The Elasticity of Productivity estimates the relationship between economic mass and productivity, or the percentage change thereof and productivity as estimated by the calculation of effective density in the 'Do Something' (with-scheme) over the 'Do Minimum' (without-scheme) scenario – identifying only the additionality.

Productivity is measured in terms of Gross Value Added (GVA) by industry sector, or output minus inputs for each industry sector in value terms. Therefore, the Elasticity of Productivity is the conversion rate of economic mass to increases in productivity.

Primary research was undertaken on behalf of TII by Professor Dan Graham at Imperial College London and Professor Edgar Morgenroth at Dublin City University (previously the Economic Social Research Institute) to estimate elasticity parameters for use in Ireland within transport appraisal[2]. Table 6.9.1 presents the elasticity parameters calculated as part of the research undertaken.

Table 6.9.1 Summary of Preferred Agglomeration Elasticity of Productivity Parameters for Ireland

Industry	NACE Code[3]	Elasticity of Productivity
Manufacturing	C	0.015
Construction	F	0.065
Transport	H & I	0.092
Fin. & Bus. Services	K, L & M	0.058

3.3.2 Distance Decay Parameters

The existence of agglomeration implies that proximity is important. There is evidence which suggests that there exists a positive relationship between productivity and agglomeration. The purpose of the distance decay function is to quantify how this benefit decreases by distance from the source. The rate of this decrease varies from sector to sector depending upon the sensitivity of production in that industry to urbanisation and localisation economies. Therefore, a distance decay parameter is required for each sector to take distance from the source into account.

Research undertaken on behalf of TII by Professor Dan Graham at Imperial College London and Professor Edgar Morgenroth at Dublin City University (previously the Economic Social Research Institute) also estimated the distance decay Parameters. Table 6.9.2 presents the distance decay and elasticity parameters calculated as part of the research undertaken.

[2] Graham. D, Evidence on the link between Productivity and Agglomeration for Ireland: Estimated Parameters for Wider Economic Benefit Calculations (2020) https://www.tii.ie/tii-library/strategic-planning/transport-research-and-information-notes(trins)/Productivity-and-Agglomeration-in-Ireland.pdf

[3] NACE Code Rev 2 – Statistical classification of economic activities in the European Community

Table 6.9.2 Summary of Preferred Agglomeration Decay Parameters for Ireland

Industry	NACE Code	Decay Parameter
Manufacturing	C	1.25
Construction	F	1.00
Transport	H & I	1.25
Fin. & Bus. Services	K, L & M	1.50

3.3.3 Productivity Data

Gross Value Added (GVA) is the standard measurement of productivity in value terms for industry sectors. GVA is similar to Gross Domestic Product (GDP) but does not account for net transfers to and from various sectors from the government via subsidies and taxes. GVA is required by sector and should be divided by the total sum of jobs in that sector to determine the GVA per worker nationally.

The Public Spending Code parameters and assumptions are presented in equity values. For these reasons, the regionalisation of impacts should not be applied. This is a particular issue in the area of transportation, where this may create a reinforcing concentration of development on larger cities such as Dublin where incomes are substantially higher than in the rest of the country.

A 2016 base year has been adopted following TAF Guidelines (2023). Table 6.9.3 illustrates the GVA per worker in each of the four industries that will be displayed within the tool. The methodology and rationale for using these GVA figures is presented in Appendix B.

Table 6.9.3 GVA per worker (Market Prices, 2016) – See Appendix B For Methodology

Industry	NACE Code	GVA per worker
Manufacturing	C	€109,370
Construction	F	€56,708
Transport	H & I	€51,901
Fin. & Bus. Services	K, L & M	€93,841

The Transport Appraisal Framework provides annual growth assumptions in relation to GNP. These values are provided in Table 6.9.4 and are applied to the GVA values presented in the Table 6.9.3 for the various industry sectors to estimate future values.

Table 6.9.4 GVA Annual Growth Assumptions

Period	Annual Growth
2016 - 2019	1.049
2020 - 2024	1.022
2025 +	1.023

3.3.4 Appraisal Discount Rate

Agglomeration impacts are generated on an annual basis over the appraisal period of the scheme, which in general will be 60 years (30-year standard appraisal period plus a 30-year residual value period).

To convert all future annual agglomeration impacts over the appraisal period back to a consistent price base year a Discount Rate per annum must be applied. The applicable Discount Rate is set by the Department of Public Expenditure and Reform (DPER) in their ‘Public Spending Code (PSC) document and the current Discount Rate is 4% (for appraisal years 1-30) and 3.5% (for appraisal years 31-60).

4. TII Agglomeration Tool – Calculation of Agglomeration Impacts

The following sections of this PAG Unit provide an overview of agglomeration, details of primary research undertaken to estimate agglomeration parameters for Ireland and the inputs required for the calculation of agglomeration impacts for National Road projects.

The Strategic and Transport Planning (STP) section of TII have developed a software tool in order to calculate the potential agglomeration impacts resulting from transport projects. Figure 6.9.1 illustrates a high-level, step-by-step overview of the tool's processes. The theory behind the tool and agglomeration as well as the tool's data assumptions, inputs and usage instruction are laid out in more detail in subsequent sections of this PAG Unit.

4.1 Overview

As outlined above, a software tool has been developed by the Strategic and Transport Planning (STP) section of TII to calculate the potential agglomeration impacts resulting from transport projects. The tool is available as an R package called `pagglomR` which can be accessed from https://tii-stp.github.io/pagglomR/

The package facilitates reading in the required input data, performing the necessary calculations and outputting the results. The package contains all the hard coded constant and economic variables (i.e. elasticity of productivity, distance decay parameters, GVA, growth rates and discount rates) outlined in Section 3.3 for each relevant industry sector.

The following scheme specific data is required by TII to run the `pagglomR` package:

- Details of Future Years (see section 4.2.1)
- Generalised Cost of Travel Input Files (Do Minimum & Do Something for each future year – see section 4.2.2)
- Jobs Data Input File (see section 4.2.3)

It should be noted that the Local Area Model (LAM) zones need to correspond with NTpM zones in order to use `pagglomR` package. Sample text input files are provided as a download from the TII website (as an attachment to PAG Unit 6.9 – Wider Impacts).

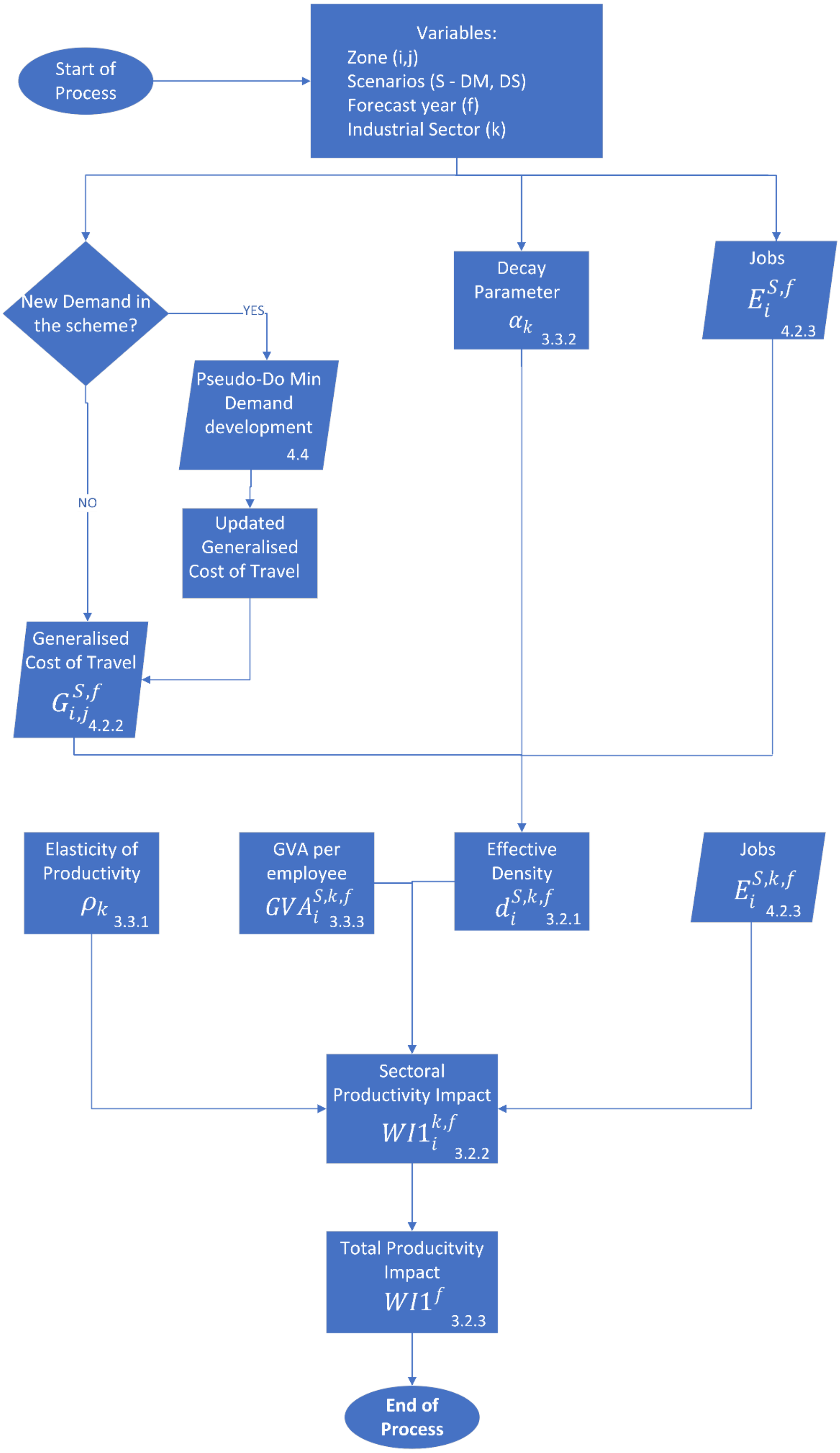

Figure 6.9.1 High-level overview of the steps involve when using the TII Agglomeration Tool[4]

[4] Parameters and variables included are discussed in subsequent sections. The subscripts in the flowchart indicate where further information is available where applicable.

4.2 Input Data

4.2.1 Future Years

The `pagglomR` package requires a minimum of 2 future years to be specified, however, to align with the modelling and appraisal of National Road projects under PAG, it is recommended that 3 future years are provided (i.e. Opening Year, Design Year (Opening +15) and Forecast Year (Opening +30)).

The `pagglomR` package will interpolate between these years to generate yearly impacts over a standard 30-year appraisal period, the residual agglomeration benefits are also calculated by the `pagglomR` package to provide impacts over a 60-year appraisal period. Future years need to be in line with the following when defined:

- Minimum of 2 future years / Maximum of 3 future years
- The time between the maximum and the minimum year has to be 30 years (i.e. standard 30 year appraisal period.

4.2.2 Generalised Cost of Travel

Data on the 'Generalised Cost of Travel' between each of the transport model zones is required. This data is required for both the 'Do-minimum' (without scheme) and the 'Do-something' (with scheme) scenarios[5]. This data is required for each modelled year as the impacts of an intervention may reduce over time as traffic levels increase. The Generalised Cost of Travel output by the traffic model includes the full total cost of travel between each zone (i.e. time, distance and tolls).

The Generalised Cost of Travel input files consist of 'impedance data' extracted from the relevant transport models for the proposed scheme. Separate input files for each of the future years and for both the Do Minimum (without-scheme) and Do Something (with-scheme) scenarios are required.

A weighted average Generalised Cost of Travel should be used where there are several peak hour traffic models. The file should be generated as a Comma Separated Value (.csv) file using the following format, an example of an input file is provided in attachment to this unit:

- Column 1 refers to the LAM Origin Zone
- Column 2 refers to the LAM Destination Zone
- Column 3 – refers to the Weighted Average Generalised Cost of Travel (in seconds) in the Do Minimum (without-scheme) Scenario

4.2.3 Jobs

Job data input is twofold, as jobs data is used to calculate both the effective density of each area and to provide scale to the impact of agglomeration on productivity. First, the total sum of all jobs is required for each transport model zone, this is inclusive of job industry sectors where agglomeration impacts have not been found. Second, the number of jobs by industry sector is required for each transport model zone where agglomeration impacts have been identified.

The Jobs Data Input file contains information about the number of jobs per LAM/NTpM zone and per industry sector. The file should be generated as a Comma Separated Value (.csv) file using the following format, an example of the input is provided in the tool:

- Column 1 refers to the zone number used in the model (NTpM or LAM)

[5] The order of the zones needs to be consistent between each input file.

- Columns 2 – 7 refers to the number of jobs in each industry sector, following this specific order; (1) manufacturing, (2) construction, (3) wholesale_retail, (4) transport, (5) inf_comm_tech and (6) Financial & Business Services
- Column 8 refers to the total number of jobs in each LAM across all industry sectors

A Comma Separated Value (.csv) file which is provided as a download from the TII website (as an attachment to this PAG Unit 6.9 – Jobs Data) provides information on the number of jobs in each industry sector for each zone in the NTpM (in 2016). NTpM jobs data for 2016 is provided in the package as a dataframe by calling the variable "ntpm_jobs".

The growth factors (multipliers) to be used to get future year jobs are also included in the package as a dataframe by calling the variable "ntpm_jobs_growth_factors".

To generate the scheme specific Jobs Input file[6], the LAM zone structure should correspond with the NTpM zone structure, whereby LAM zones are defined as subzones of NTpM zones to avoid any overlapping of LAM zones between adjacent NTpM zones.

The NTpM jobs data by sector can be disaggregated to the LAM zones by applying the same process used to disaggregate trip demand from an NTpM zone to a LAM zone (i.e. the total number of jobs by industry sector in an NTpM zone can be allocated to the LAM sub-zones in a proportionate manner that reflect the level of traffic demand with the LAM zone).

4.3 Geographic Area of Impact

The inputs for the `pagglomR` package will come from a transport model which may be a local area model or a more strategic regional model encompassing different geographical areas around the country.

The impacts of the scheme in question may be focussed on a specific sub-set of transport model zones, rather than on all zones in the model. Particular issues may arise when using a model at a regional or national scale, where demand changes and/or cost impacts are present in zones on the periphery of the model and not within the expected area of influence of the scheme. These impacts may be down to issues with model convergence and or model 'noise', as opposed to scheme impacts.

Expert judgement should be used to determine whether modelled impacts that occur in zones located outside the expected area of influence of a scheme are due to model convergence and noise, rather than scheme impacts. This should be based on an understanding of the geographical scope of the travel market and key origins and destinations, and an analysis of the geographical extent of current and future transport problems. It should also be based on a detailed knowledge of the transport model used for the analysis.

Any decision to reduce the geographical area of impact to a subset of zones for the appraisal of scheme impacts should be backed up by appropriate analysis and narrative and documented in the appraisal deliverables. Generally, this area of influence should be consistent between the appraisal of user impacts using TUBA and the appraisal of agglomeration impacts using the `pagglomR` package, i.e. demand and cost skim data should be consistent in each analysis.

4.4 Cases of New Demand

In cases where new demand is created by the proposed intervention additional steps must be considered.

[6] Please note that the sequence of zone numbers in the jobs file should be in same order as the zone numbers in the origin zone column of the generalised cost file.

As the Generalised Cost of Travel is weighted by demand, zones with no demand in the Do Minimum can artificially deflate the results of the analysis of agglomeration impacts. For example, if there is no demand in the Do Minimum scenario, but there is demand in the Do Something scenario, the Generalised Cost of Travel will appear to be increasing as a result of the scheme, which is not true.

This issue will only arise where the transport model assesses variable demand impacts, and the scale of these impacts may be limited to a small number of zones or a specific geographic area.

Guidance is provided in the TUBA General Guidance and Advice document with regard to using the triangle method to create a pseudo-do minimum to replace the original Do Minimum[7]. This pseudo-do-minimum can then be used to obtain non-zero demand figures for the Do Minimum scenario. These new demands can be used in the weighted Generalised Cost of Travel for the Do Minimum scenario.

There may be alternative modelling/appraisal approaches to understand these impacts and it is the responsibility of the modelling/appraisal team to provide clarity in their approach to potential issues arising from the creation of new demand. For example, if the impacts are limited to a certain geographic area in the model that is outside the area of influence of the proposed scheme, the best solution may be to exclude this area from the benefits calculation.

4.5 Results

The output files from the `pagglomR` package contain the following summary information:

- Agglomeration values (discounted values)
- 30-year standard approval period agglomeration values
- Residual agglomeration values (additional 30-year period)
- Agglomeration values by zone and sector

The results provided by the `pagglomR` package will inform the economic case for the proposed scheme and may be provided as a sensitivity test as part of the scheme relevant Business Case at Phase 3 (Design & Environmental Evaluation) and Phase 5 (Enabling & Procurement) subject to TII and DoT approval. An example of the results report that can be output by the `pagglomR` package is provided in Appendix A of this PAG Unit. Further guidance on the use of the tool is available at https://tii-stp.github.io/pagglomR/index.html under the ‘Articles’ section.

[7] https://tagsoftware.co.uk/link-page/TUBA > “Document Bundle” > “TUBA v1.9.14 General Guidance and Advice”

5. Increased Output of Firms in Imperfectly Competitive Markets

The vast majority of markets for goods and services are not perfectly competitive. This means that output is lower and prices are higher than they would be if the market in question was perfectly competitive. In such a market a reduction in the costs faced by firms will lead to increased production, lower prices and an increase in economic welfare. Transport investment can provide such a reduction in costs as they reduce the transport costs faced by businesses. This is one of the Wider Impacts of a transport investment.

Markets will tend to be at least slightly imperfect even in developed economies due to product differentiation and transport costs. Through product differentiation a firm attempts to achieve the position of a monopolist so as to maximise its profits. High transport costs can also lead to areas becoming geographically isolated permitting businesses to increase prices above marginal cost.

The best available research on the likely size of this benefit remains a 1999[8] study undertaken for the UK Standing Advisory Committee on Trunk Road Appraisal (SACTRA). This study demonstrated that the wider impact for increased outputs in imperfectly competitive markets could be calculated as a function of business and freight user benefits. These user benefits can be uplifted by a factor that is itself a product of the elasticity of demand and the ratio of the price-marginal cost margin to price.

For the UK it is argued that the price – marginal cost margins are approximately 20% of 'shop' prices and the average elasticity of demand for goods and services is 0.5. An uplift factor of 10% to business and freight user benefits is therefore applied in the UK[9] to capture the wider impact of increased output of firms.

More recent research for the Scottish Government identified that price – cost margins in very remote areas may be much higher than elsewhere in the UK[10]. Very remote areas are defined as locations that are more than one hour travel from a settlement of 10,000 people or more. This conclusion was based on an analysis of the supply of petrol for which a government investigation had recently been completed. As a consequence, the Scottish Government use an uplift on business and freight user benefits of 20% for trips with an origin or destination in a very remote area. The limited evidence for this uplift means that the additional wider impact due to remoteness is treated as a sensitivity to the core analysis[11].

5.1 Recommended Appraisal Method

In the absence of specific data for Ireland it is recommended that the UK data and method is utilised. That is:

$$\text{Wider impact of increased output by firms} = 0.1 \times \text{Business and freight user benefits}$$

[8] Venables, A.J. and M. Gasiorek (1999) The Welfare Implications of Transport Improvements in the Presence of Market Failure. In: SACTRA (ed). The welfare implications of transport improvements in the presence of market failure and the incidence of imperfect competition in UK sectors and regions. London: Department for the Environment, Transport and the Regions, pp. 3-58.

[9] Department for Transport (UK) (2014), TAG Unit A2.1 Wider Impacts

[10] Laird, J. and P. Mackie (2009) Review of Economic Assessment in Rural Transport Appraisal. Edinburgh: The Scottish Government. ISBN 978 0 7559 7701 7 (Web only publication) http://www.scotland.gov.uk/Publications/2009/10/29110947/0

[11] Scottish Government (2009) Economy Objective, Scottish Transport Appraisal Guidance (STAG). The Scottish Government. http://www.transportscotland.gov.uk/stag/td/Part2/Economy

Business and freight user benefits are defined as the change in consumer surplus for the business and freight modes over all types of user benefit (time savings, vehicle operating cost savings, toll/fare changes, reliability benefits, etc.) Further information on the calculation of Business and Freight User Benefits is provided in PAG Unit 6.1 - Guidance on Conducting CBA. It should be noted that the 0.1 multiplier should be used for all areas of Ireland.

6. Other Impacts

Other market failures that can give rise to wider impacts are also theoretically possible. From a practical perspective it is however recommended that these impacts are excluded from the appraisal process. This is due to either a lack of evidence or the large resource implications needed for their appraisal – or in some instances a mixture of both. The particular circumstances required for each impact are discussed in more detail in the following sections.

6.1 Employment Benefits from Increased Labour Supply

For the same reason that employment during construction will generate a wider impact, an increase in the supply of labour will also create a positive impact – providing that labour is supplied by taking workers out of unemployment rather than through increased immigration (or the return of expatriate workers).

Given that the impacts of a transport improvement on employment is in the main re-distributional, the required analysis to estimate at a national level the gain in employment and the proportion of that arising to workers previously unemployed is non-trivial, whilst the benefit anticipated is likely to be small (as transport schemes do not generally have a large impact on employment at the national level).

The level of resources required to estimate employment benefits from increased labour supply is therefore not proportionate to the resulting improvement in the robustness of the appraisal.

6.2 Tax Benefits

Income tax creates a market failure in the labour market. A transport improvement that affects either the number of people employed in the whole economy or average earnings therefore creates an additional welfare benefit. This is equivalent to the change in income tax revenues. Specific tax benefits will arise from:

- Increased productivity of workers due to agglomeration impacts;
- Increased supply of labour at the national level; and
- Increased average productivity of workforce due to relocation of businesses/economic activity to more productive locations.

Each of these reasons is very resource intensive in terms of their estimation. Estimating both changes in productivity due to agglomeration and increases in the supply of labour have already been discussed. Predicting where economic activity will relocate to and whether it is relocating from a low productive area to a higher productive area would require at the minimum some form of Land-Use Transport Interaction (LUTI) modelling. It would also require earnings data by sector at a disaggregated geographic level.

6.3 Inward Investment Impacts

Foreign Direct Investment (FDI) can have a positive impact on an economy. If transport investment can facilitate inward investment, then some of the spin off benefits from the FDI can be additional to transport user benefits. One of the principal spinoff benefits are productivity spillovers arising through knowledge transfer and enhanced competition in domestic markets. FDI can also have additional welfare benefits if employment is created in areas of structural unemployment.

The difficulty in including inward investment impacts in a transport appraisal has two main themes. Firstly, there is little to no reliable evidence on either how transport affects inward investment or how inward investment impacts on productivity[12]. The second theme is that the wider impact of inward investment may be double counted in other wider impacts – most notably agglomeration impacts as confounding means the agglomeration impact measures more than just agglomeration. The impact on employment would also be addressed in the wider impact of employment benefits from increased labour supply.

6.4 Re-organisation Impacts

Reductions in transport costs can allow businesses to centralise activities at fewer sites. This is very noticeable in the freight sector but is also evident in many other sectors. Re-organisation by businesses occurs as the transport improvement allows them to take advantage of economies of scale in production thereby increasing productivity. The presence of economies of scale is a market failure as prices will depart from marginal social cost. The most effective way of capturing economies of scale in production in a cost benefit analysis is through the use of a spatial computable general equilibrium model. Such models however are beyond the scope of almost all transport appraisals. It is also noted that some confounding of economies of scale effects and agglomeration impacts will occur, if an attempt is made to estimate re-organisation impacts in isolation. Only the very largest projects in Ireland could possibly warrant such a research-intensive approach.

6.5 Thin Labour Market Impacts

The presence of search costs in remote and isolated labour markets leads to a market failure. Employment creation in such labour markets would therefore generate a welfare benefit additional to user benefits. To date however there is insufficient evidence on the functioning of remote labour markets in Ireland and the scale of the search costs relative to the wage. The latter is important as it determines the welfare benefit of increased employment.

[12] NERA (2009) Transport's Role in Facilitating International Business. Report to the Department for Transport.

Appendix A:

Sample `pagglomR` Output Report

Analysis of Agglomeration Impacts

N99 Upgrade Scheme
26th October 2023

Scenario: Central Growth Scenario
Opening Year: 2024

General Appraisal Input Parameters

Parameter	Value
Scheme Opening Year	2024
Discount Rate (Year 1-30)	4.0%
Discount Rate (Year 31-60)	3.5%
Discount Rate (Year 61-90)	3.0%
Assumed annual GVA growth rate (2020-2024)	2.2%
Assumed annual GVA growth rate (2025+)	2.3%

Agglomeration Calculation Input Parameters

Sector	GVA per worker	Distance decay parameter	Elasticity of effective density to productivity
Manufacturing	€ 109,370	1.25	0.015
Construction	€ 56,708	1.00	0.065
Wholesale_Retail	€ 0	1.00	0.000
Transport	€ 51,901	1.25	0.092
Inf_Comm_Tech	€ 0	1.50	0.000
Fin_Bus_Services	€ 93,841	1.50	0.058

Summary of Agglomeration Impacts

Appraisal period	Present Value Benefits (2016 prices)
30 year benefits	€ 113,405,655
Residual value benefits	€ 75,554,188

Total Agglomeration Benefits: € 188,959,842

Table of Agglomeration Impacts

Year	Modelled Benefits	Nominal Benefits	Present Value Benefits (2016 prices)
2020	€ 0	€ 0	€ 0
2021	€ 0	€ 0	€ 0
2022	€ 0	€ 0	€ 0
2023	€ 0	€ 0	€ 0
2024	€ 4,573,862	€ 6,175,035	€ 4,512,038
2025	€ 4,597,914	€ 6,350,281	€ 4,461,623
2026	€ 4,621,967	€ 6,530,321	€ 4,411,651
2027	€ 4,646,020	€ 6,715,284	€ 4,362,121
2028	€ 4,670,073	€ 6,905,301	€ 4,313,031
2029	€ 4,694,126	€ 7,100,506	€ 4,264,380
2030	€ 4,718,179	€ 7,301,038	€ 4,216,167
2031	€ 4,742,231	€ 7,507,038	€ 4,168,392
2032	€ 4,766,284	€ 7,718,651	€ 4,121,051
2033	€ 4,790,337	€ 7,936,028	€ 4,074,145
2034	€ 4,814,390	€ 8,159,321	€ 4,027,670
2035	€ 4,838,443	€ 8,388,687	€ 3,981,627
2036	€ 4,862,495	€ 8,624,288	€ 3,936,012
2037	€ 4,886,548	€ 8,866,289	€ 3,890,825
2038	€ 4,910,601	€ 9,114,859	€ 3,846,064
2039	€ 4,934,654	€ 9,370,174	€ 3,801,726
2040	€ 4,932,884	€ 9,582,250	€ 3,738,241
2041	€ 4,931,114	€ 9,799,124	€ 3,675,816
2042	€ 4,929,344	€ 10,020,906	€ 3,614,433
2043	€ 4,927,575	€ 10,247,706	€ 3,554,074
2044	€ 4,925,805	€ 10,479,638	€ 3,494,723
2045	€ 4,924,035	€ 10,716,818	€ 3,436,363
2046	€ 4,922,265	€ 10,959,364	€ 3,378,977
2047	€ 4,920,495	€ 11,207,398	€ 3,322,548
2048	€ 4,918,725	€ 11,461,044	€ 3,267,062
2049	€ 4,916,955	€ 11,720,430	€ 3,212,501
2050	€ 4,915,185	€ 11,985,684	€ 3,158,852
2051	€ 4,913,416	€ 12,256,939	€ 3,106,098
2052	€ 4,911,646	€ 12,534,332	€ 3,054,225
2053	€ 4,909,876	€ 12,818,002	€ 3,003,217
2054	€ 4,908,106	€ 13,108,089	€ 2,967,327

Year	Modelled Benefits	Nominal Benefits	Present Value Benefits (2016 prices)
2055	€ 4,908,106	€ 13,409,575	€ 2,932,924
2056	€ 4,908,106	€ 13,717,995	€ 2,898,919
2057	€ 4,908,106	€ 14,033,509	€ 2,865,308
2058	€ 4,908,106	€ 14,356,280	€ 2,832,087
2059	€ 4,908,106	€ 14,686,474	€ 2,799,251
2060	€ 4,908,106	€ 15,024,263	€ 2,766,796
2061	€ 4,908,106	€ 15,369,821	€ 2,734,717
2062	€ 4,908,106	€ 15,723,327	€ 2,703,011
2063	€ 4,908,106	€ 16,084,963	€ 2,671,671
2064	€ 4,908,106	€ 16,454,918	€ 2,640,695
2065	€ 4,908,106	€ 16,833,381	€ 2,610,079
2066	€ 4,908,106	€ 17,220,548	€ 2,579,817
2067	€ 4,908,106	€ 17,616,621	€ 2,549,906
2068	€ 4,908,106	€ 18,021,803	€ 2,520,342
2069	€ 4,908,106	€ 18,436,305	€ 2,491,120
2070	€ 4,908,106	€ 18,860,340	€ 2,462,238
2071	€ 4,908,106	€ 19,294,128	€ 2,433,690
2072	€ 4,908,106	€ 19,737,893	€ 2,405,474
2073	€ 4,908,106	€ 20,191,864	€ 2,377,584
2074	€ 4,908,106	€ 20,656,277	€ 2,350,018
2075	€ 4,908,106	€ 21,131,371	€ 2,322,771
2076	€ 4,908,106	€ 21,617,393	€ 2,295,841
2077	€ 4,908,106	€ 22,114,593	€ 2,269,222
2078	€ 4,908,106	€ 22,623,229	€ 2,242,912
2079	€ 4,908,106	€ 23,143,563	€ 2,216,907
2080	€ 4,908,106	€ 23,675,865	€ 2,191,204
2081	€ 4,908,106	€ 24,220,410	€ 2,165,799
2082	€ 4,908,106	€ 24,777,479	€ 2,140,688
2083	€ 4,908,106	€ 25,347,361	€ 2,115,869

Analysis completed 2023-11-29 13:03:05[13]

[13] Analysis undertaken using `pagglomR()` package in `R` - version no. 0.3.0 developed and maintained by TII

Appendix B:

Methodology for Calculating GVA per Worker Figures

Table 6.9.3 from Section 3.3.3 illustrates the GVA per worker in each of the four industries that will be displayed within the tool.

Table 6.9.3 GVA per worker (Market Prices, 2016) – See Appendix B For Methodology

Industry	NACE Code	GVA per worker (€)
Manufacturing	C	€109,370
Construction	F	€56,708
Transport	H & I	€51,901
Fin. & Bus. Services	K, L & M	€93,841

The methodology and rationale for using these GVA figures is presented below for each industry.

1. **Manufacturing (NACE Code C)**

   The methodology for calculating GVA per worker for the manufacturing sector was to use data from the Annual Business Survey of Economic Impact (ABSEI) from the Department of Enterprise, Trade and Employment.

   It was decided not to use CSO data estimating GVA per worker for the Manufacturing sector due to the distortionary effects of contract manufacturing which results in the severe overestimation of productivity per worker. The solution applied was to adopt GVA per worker for domestic firms only, through using the ABSEI and forecasting for future years using GNP growth per capita - which is a proxy for economic growth. According to the 2021 ABSEI report[14], the total GVA for domestic manufacturing firms was €12,044 million (Factor Cost, 2021 Prices) and the number of employees is 119,387. This gives us a GVA per worker at factor cost of €100,882 (Factor Cost, 2021 Prices). Converting this to market prices (by adding the 16% indirect tax correction factor as per TAF[15]) gives a GVA per worker of €117,023 (Market Prices, 2021). This was then deflated to 2016 prices for use in the tool giving a parameter of €109,370 (Market Prices, 2016).

2. **Construction (NACE code F)**

   The methodology for calculating GVA per worker for the construction sector was as follows. The total GVA for the sector was taken from CSO figures published in the Annual National Accounts for 2022[16] whilst the employment figures for the sector were sourced from the CSO labour force survey[17]. This gave us a GVA per worker figure of €65,665 (Market Prices, 2022). It was necessary to deflate these to reflect a 2016 base year, which gave our parameter of €56,708 (Market Prices, 2016).

[14]ABSEI Report 2021: https://www.gov.ie/pdf/?file=https://assets.gov.ie/255733/19fd03ba-b1c4-4960-ba53-714be453e82d.pdf#page=null
[15] TAF Module 8 – Detailed Guidance on Appraisal Parameters: 1a7ff966-44cf-4aed-b1a0-bc9c746d294a.pdf (www.gov.ie)
[16] Annual National Accounts 2022 - https://www.cso.ie/en/releasesandpublications/ep/p-ana/annualnationalaccounts2022/gdpbyincomes/grossvalueaddedbyactivity/
[17] CSO Labour Force Survey - https://data.cso.ie/table/QLF03

3. Transport (NACE Codes H & I)

The methodology for calculating the GVA per worker for the 'Transport' sector is calculated by combining the sectors of 'Transportation and Storage' (NACE Code H) and 'Accommodation and Food' (NACE Code I). Similar to Construction, the total GVA figures for both sectors were taken from the Annual National Accounts for 2022 and the employment figures were taken from the labour force surveys. The total GVA & workers for both Sectors H & I which were reported in the survey were combined in order to estimate the 'Transport' GVA per worker. This is displayed in Table 6.9.5.

Table 6.9.5 GVA per worker for the Transport Sector NACE Codes H & I (Market Prices, 2022)

Industry	Total GVA (€M)	Number of workers	GVA per worker (€)
H – Transportation and Storage	9,975	110,900	89,946
I – Accommodation and Food	7,117	173,500	41,020
Transport (H&I Combined)	17,092	284,400	60,098

The GVA per worker for transport is therefore equal to €60,098 (Market Prices, 2022). It was necessary to deflate this (as above) in order to have it reflected in 2016 prices. This gave us our parameter of €51,901 (Market Prices, 2016).

4. Financial and Business Services (NACE codes K, L & M)

Similar to the Transport Sector, the parameter for 'Financial and Business Services' within the tool is a combination of sectors. This time being a combination of 'Financial and Insurance Activities' (NACE Code K), 'Real Estate' (NACE Code L) and 'Professional, Scientific and Technical Activities' (NACE Code M). All three of which are included within the Business in Ireland Survey 2019. The total GVAs and workers are combined in Table 6.9.6 in order to estimate the 'Financial and Business Services' GVA per worker. This is displayed in the table below (these figures have been converted from factor prices to market prices as above).

Table 6.9.6 GVA per worker for the Financial and Business Services Sector NACE codes K, L & M (Market Prices, 2019)

Sector	Total GVA (€M)	Number of workers	GVA per worker (€)
K - Insurance	4,741	-	-
K - Banks	6,141	-	-
K - Total	10,881	106,603	102,079
L – Real Estate	2,283	32,870	69,452
M – Professional, Scientific and Technical Activities.	16,648	170,797	97,477
Total	29,814	310,270	96,089

The GVA per worker for the 'Financial and Business' sector therefore equal to €96,089 (Market Prices, 2019).

It was necessary to deflate this (as above) in order to have it reflected in 2016 prices. This gave us our parameter of €93,841 (Market Prices, 2016).

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