



Re-appraising ‘in-process’ benefits of strategic infrastructure improvements: Capturing the unexpected socio-economic impacts for lagging regions

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ABSTRACT

The paper explores the scope of transportation infrastructure appraisal approaches for capturing in-process (during design/development and construction) socio-economic impacts. In-process socio-economic impacts are explored through the case of a major road infrastructure improvement programme in South Wales, United Kingdom. The study posits that monitoring in-process benefits can provide a more holistic understanding of impacts to better inform appraisal approaches, addressing concerns over existing appraisal transparency and accountability. Advancing monitoring and appraisal in this way means that more unexpected socio-economic outcomes for regional economies can be understood. These impacts are illustrated through the labour market, skills and wider supply side legacy benefits resulting from direct project activity. The paper reveals the potential outcomes of capturing these in-process socio-economic benefits when supporting local economies in lagging regions.

1. Introduction

This paper examines current transport infrastructure appraisal techniques in the light of a paucity of attention given in these techniques to in-process (i.e. design/development and construction stage - see below) socio-economic benefits occurring in the local economy surrounding the development. The benefits of a more explicit consideration of in-process benefits of road infrastructure projects is considered, particularly in the context of lagging regions responding to persistent periods of low-growth and development. While the paper focuses on the case of a road development in one disadvantaged region, it has both practical and policy implications to different types of infrastructure projects.

Cost-benefit analysis (CBA) is regularly critiqued by those calling for more nuanced understandings of socio-economic impacts (Macharis and Bernardini, 2015; Odeck and Kjerkreit, 2019; Lucas et al., 2022). There have been calls to recognise the dynamic socio-economic outcomes that are often context-specific on infrastructure improvements. These calls have led to a New Approach to Transport Appraisal (NATA), based on a Multi-Criteria Analysis (MCA) inclusive of economic, environmental, social and spatial impacts (Barradale and Cornet, 2018; Macharis and

Bernardini, 2015). There are additional debates centring on the relative merits of *ex-ante* infrastructure appraisal and *ex-post* appraisal (Odeck and Kjerkreit, 2019; Salling and Banister, 2009). Yet, there is rather less discussion relating to appraisal of in-process benefits with these often excluded from, or discounted heavily in, both *ex-ante* and *ex-post* infrastructure analysis. While there is an argument that in-process development and construction benefits should be appraised separately (Boardman et al., 1994; Laird and Venables, 2017; SACTRA, 1999) this paper suggests that their exclusion prevents a holistic understanding of the transport infrastructure process. Furthermore, in separate appraisal, the social and economic importance of legacy foundations evolving during the development and construction process, and how these support *ex-post* development outcomes resulting from infrastructure development, could be missed.

The paper uses mixed methods to examine the socio-economic impacts coming from the construction and operations (in-process) stage of road infrastructure improvements. In doing so, the paper seeks to understand whether the under-explored in-process stage of large-scale infrastructure improvements provide regional economic development outcomes for lagging regions. Practical, theoretical and policy implications are derived from the case of the A465 Head of the Valleys trunk

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road improvements in South Wales, United Kingdom.

‘In process’ here captures the host of operational and development processes involved in implementing and overseeing the road project aims. This includes recruitment and training of the workforce; purchasing of necessary goods and services; and the physical infrastructure construction operations. Often these processes are connected to the early identification of the need for the road and the development of the initial business case. A central reason why these in-process benefits have been overlooked is because the regional gains are considered temporarily transferred from another area and obscured by externalities (Boardman et al., 1994; Laird and Venables, 2017; SACTRA, 1999). It is also important to show that ‘in-process’ might be understood differently according to how infrastructure projects are financed. For example, the development process under an ‘early contractor involvement’ might be quite different from that in a design, build and operate contract whereby the ‘process’ for the contractor involves an extended phase of operating the asset and receiving public monies by way of a services contract. However, for the case discussed in this paper, i.e. early contractor involvement, ‘in-process’ is understood to embrace design, development and build through to handover.

This paper demonstrates the under-explored benefits of monitoring in-process road infrastructure projects for regional economies. Responding to the paucity of in-process infrastructure appraisals, data supporting this paper was collected and analysed at six-month intervals between 2015 and 2021 to measure and evaluate emerging socio-economic outcomes over an extended period. The study reveals advances in the labour market, skills and wider supply side legacies for the lagging region. The paper demonstrates the potential benefits of monitoring and appraising such in-process benefits showing how this might strengthen the wider socio-economic impacts of the road once construction and operations are complete. The paper also contributes to regional economic development theory by identifying how in-process benefits may support local economies during periods of prolonged economic difficulties.

The remainder of the paper is structured as follows. The next section provides an overview of literature on road infrastructure and appraisal methodologies, seeking to develop a case for a better understanding of in-process benefits that can support local economies. The third section describes the Head of the Valleys road, and the fourth focuses on the methods used to examine in-process benefits. The fifth section presents the findings of the selected in-process benefits for the local economy surrounding the road development. The final sections discuss the relevance of the findings, limitations and future research.

2. Appraising road infrastructure development

Concerns relating to the methods used in transport infrastructure appraisal have led to a resurgence of academic and policy attention. In part this links to public demands for value for money during periods of financial austerity, and with interest amplified by the growing number of high-profile transportation and infrastructure projects experiencing cost overruns. Clearly several characteristics of large transport infrastructure projects can create problems for forecasting costs and benefits including long time horizons and with projects made complex by having many actors involved and with problems of conflicting interests. Moreover, there can be issues around infrastructure ‘goal posts’ changing mid project. Indeed Flyvbjerg (2007, 2009) shows that gaps between *ex ante* estimates of costs and benefits and out-turn can be vast, leading to heightened mistrust of conventional cost-benefit analysis and calls for alternative appraisal methods including reference case forecasting (see Flyvbjerg et al., 2016). These difficulties are partly seen to relate to problematic incentives for developers to overstate benefits and understate costs and a systemic optimism bias that is not supported by the evidence, and then with what Flyvbjerg describes as something akin to the ‘survival of the unfittest’ in terms of infrastructure projects. Of course, overrepresentation of benefits might also be an issue in terms of

inflating the economic benefits occurring during the development and construction process of road infrastructure. More generally Flyvbjerg (2007, 2009) reveals a paucity of information in respect of actual benefits and risks associated with infrastructure projects. This debate remains pertinent given continued calls for transparency and value in procuring large public sector contracts (Penyalver et al., 2019). Running parallel is a recurring debate on appropriate means to foresee and prevent these difficulties (Kelly et al., 2015; Flyvbjerg et al., 2016; Laird and Venables, 2017), most notably through using appropriate appraisal techniques when investing in, and evaluating, transportation infrastructure.

This section reviews recent advances in transportation appraisal approaches that embrace social and economic considerations. The appraisal approaches are then linked to current evaluations of transport infrastructure on regional economies, with socio-economic outcomes being largely associated with the outcomes stemming from the completed infrastructure rather than the benefits accrued during the construction stage. This paper suggests that these omitted benefits can be monitored, supported and enhanced during the lifetime of the infrastructure development, which may bring longer-term local and regional economic development opportunities. The review seeks to make the case that road appraisal needs to be holistic and should advance understanding of how in-process benefits lead to a longer-term socio-economic legacy in terms of strengthening the local economy.

2.1 ‘Re-appraising’ the transportation investment appraisal process

The range of benefits included in conventional CBA has been subject to scrutiny (Atkins et al., 2017; Kelly et al., 2015; Laird and Venables, 2017). In the case of road construction, a narrow remit of benefits is typically incorporated (Kelly et al., 2015; Lucas et al., 2022), with some prioritisation of welfare benefits to road users. These benefits tend to major on what can reasonably be measured and valued, such as time-savings for commuters and suppliers, alongside monetised savings from improved safety, environmental impacts and reduced noise (Odeck and Kjerkreit, 2019). Such appraisal methods are widely used, but with a continued scrutiny of their limitations (Laird and Venables, 2017; Odeck and Kjerkreit, 2019).

Scrutiny also focuses on the economic ‘distance’ between *ex-ante* and then *ex-post* evaluations (Flyvbjerg, 2007, 2009; Kelly et al., 2015; Odeck and Kjerkreit, 2019). CBA are chiefly undertaken *ex-ante* when determining the feasibility of a project or selecting the most economically viable project *before* the construction occurs. *Ex-ante* valuations rely on estimates of future benefits (Boardman et al., 1994; Love et al., 2016; Salling and Banister, 2009), and with additional problems resulting from analyses undertaken by those with vested financial or other interests (Flyvbjerg, 2007; Beukers et al., 2012). In contrast, *ex-post* appraisal after the construction work is complete (Kelly et al., 2015; Odeck and Kjerkreit, 2019), might include consideration of longer-term intergenerational benefits and selected elements of socio-economic legacy (Penyalver et al., 2019). However, even *ex-post* analysis is typically constrained by a focus on time saved, safety, environmental factors, and with difficult assumptions required in monetary valuation (Kelly et al., 2015).

More recent work has examined a wider set of dynamic effects associated with transport infrastructure, including effects on urban productivity, employment, sustainability and economic growth (Kelly et al., 2015; Melo et al., 2013; Mullen and Marsden, 2015; Laird and Venables, 2017; Penyalver et al., 2019; and aspects of SACTRA, 1999). These wider effects also include the social consequences of transport decision-making for passenger and community well-being, with a focus on passengers’ transport experience (Carse, 2011), as well as the accessibility, health and community benefits (Jones and Lucas, 2012; Lucas et al., 2022). As such a *New Approach to Transportation Appraisal* (NATA) encompasses multi-criteria analysis (MCA) processes that allow for the inclusion of an array of criteria that can be shaped depending on

the context (Barradale and Cornet, 2018; Macharis and Bernardini, 2015). These approaches encompass a number of quantitative and increasingly qualitative criteria, with decisions being evaluated based on the projected and actual economic, social, environmental, technical and spatial outcomes. Approaches that encompass multiple criteria and actors (Macharis and Bernardini, 2015) demonstrate the importance of adapting the appraisal process depending on the people, place and processes. It is accepted that this can run counter to a need for a standardised appraisal method whereby the same criteria are used to consider road investments in a consistent manner.

While it has been argued that dynamic socio-economic outcomes have a place in the road appraisal process (SACTRA, 1999), these effects are often supplementary or undervalued (Atkins et al., 2017). Even where analysis of new transport infrastructure seeks to embrace a wider set of economic development benefits, these are often understood as being connected with the completion of the infrastructure.

In summary there is a paucity of work that focuses on in-process benefits obtained during the project development and construction phases of a road infrastructure project. When evaluating the socio-economic impacts for regions, benefits can be attained by considering the infrastructure developments as they progress and recognising the multifaceted ways these implications can be (re)attained, monitored and evaluated. This paper outlines the socio-economic outcomes identified during the development and construction (in-process) stage, proposing that a greater focus on these can allow for *ex-post* outcomes to be better developed and understood. In doing so, the in-process outcomes can enable regions to develop their longer-term supply legacies and capture improvements within the regional economy when planning and implementing a robust economic development process.

3. Case: A465 Heads of the Valleys Road

This paper investigates in-process socio-economic benefits from improvements to the A465 trunk road in South Wales, United Kingdom. The A465 Heads of the Valleys road is strategically important, forming part of the Trans European Transport Network. Extending from Abergavenny at its eastern end and joining the M4 at Llandarcy near Swansea, the route provides an alternative east/west route from the Midlands to west Wales and the Irish ferry ports.

Much of the original route, constructed in the 1960's, became substandard and unsafe. The Welsh Government objective was to dual the road to modern highway standards, together with providing grade separated junctions. Road improvement demands also linked to a strong growth of inward manufacturing investment into the Heads of the Valleys corridor after the 1980s. To facilitate delivery, the National Transport Plan divided A465 works into six sections (see Appendix 1 – for timings, completions and map). The course of the A465 development has seen an evolution in procurement process. Sections 1 and 4 of the road development (see Appendix 1) were procured by Welsh Government as design and build contracts. However, for Sections 2 and 3 the procurement method was an early contractor involvement process (ECI). In the Section 2 element which is examined in this paper, the managing contractor was involved in the early-stage development of the road (i.e. the process elements associated with outline, design, planning, cost estimation and statutory processes) and with this leading to a target cost. There was then a stage in the process whereby Welsh Government and the managing contractor had the choice on whether to proceed to the build phase prior to the handover of the road to Welsh Government. In the most recent sections to be developed (Sections 5 and 6 Dowlais Top to Hirwaun), Welsh Government has moved to a different Mutual Investment Model (MIM). This has partly linked to a shortage in public funds available to finance recent capital projects in Wales. The MIM involves private sector firms designing, financing and operating assets, and with Welsh Government paying a fee. The road then only enters into public ownership after a period of private operation of the road.

Section 2 of the A465 improvements extended for 8.1 km from

Brynmawr in the West to Gilwern in the East. This section was challenging in engineering and geological terms. Both Sections 2 and 3 also occurred during a period when the Welsh Government heightened its focus on aligning infrastructure projects with local economic development outcomes, particularly through the construction phase (National Infrastructure Commission Wales, 2018). In 2017, the Welsh Government launched their updated Welsh Transport Appraisal Guidance. The guide set out a series of best practices for transportation infrastructure appraisal aligned to the well-being objectives within the Well-being of Future Generations (Wales) Act 2015, encompassing sustainable, equitable and “well-connected resilient environments for everyone in Wales” (Welsh Government, 2017; 1). The case selection also reflects a shift in current guidance to encompass three stages of transport appraisal; the rationale objective appraisal (*ex ante*), implementation monitoring (*in-process*) and evaluation feedback (*ex post*). The implementation stage advocated the use of periodic reports to extrapolate benefits and mitigate against negative consequences. These developments reflect the wider acceptance of the implementation stage as an important source of appraisal information for public sector procurement (Treasury, 2018).

The focus on improving transport connectivity in Wales (National Infrastructure Commission Wales, 2018), included a commitment to support less prosperous regions. Sections 2 and 3 extend west across the Blaenau Gwent local authority area and then across to Tredegar, and then Merthyr Tydfil and embrace some of the most deprived communities in Wales (Welsh Government, 2019). Responding to the persistent socio-economic problems, the potential to build community and labour market benefits were incorporated into the design and planning stages (Constructing Excellence Wales, 2015). Employment and training targets were also aligned with the Welsh Government's procurement strategy *Delivering Maximum Value for the Welsh Pound* (Welsh Government, 2014).

Research has been completed in respect of the A465 improvements. Lucas et al. (2022) developed a mixed methods approach to explore the social impacts of the A465 road development, seeking to bring to the fore ‘hard to reach’ voices. This was linked to a GIS analysis of secondary datasets. They concluded that some of the social benefits from the A465 for local people could have been improved and with some of the dis-benefits potentially avoided had a proper social assessment been used in the decision process on the roads design and development. This was developed in terms of an *ex ante* and *ex post* case study. The research for the present paper was more focused on in-process issues around economic as opposed to social outcomes, and then with links to regional economic development outcomes.

4. Mixed methods approach

The study adopted a mixed methods approach. This included a quantitative analysis of the direct, indirect (supply chain) and induced (household) socio-economic benefits derived from spending on the scheme. Longitudinal data was collected on spending, wages, employment and goods and services procurement from the managing contractors overseeing the road improvement. In relation to Section 2, which is the primary data focus of this paper, information was collected at six-monthly intervals between 2015 and 2021. Information sources from the managing contractor included the wage bill linked to direct and temporary staff and estimations of related staff numbers; spending on plant and materials, as well as other goods and services (including details on where the items were sourced); subcontractor location, activity and spend as well as the number of subcontractor persons per week per site. The reliability of the information sources was verified in accordance with company accounts, web materials and data obtained directly from subcontractors through a brief spending survey.

Important for the research was the exploration of the magnitude of the direct spending by the managing contractor and subcontractors. An analysis of the spending of the managing contractor revealed much about the direct effects in the Welsh economy, but the analysis of this

operational spend would not permit the identification of wider supply chain effects linked to this spending. For example, where there is an increase in final use for the output of an industry, it is assumed there is an increase in output of the same industry. This is the direct effect explained above. However, as the producers increase their outputs there will also be some increase in use on their suppliers and so on down the supply chain; this is an indirect effect. The ratio between direct plus indirect effects and direct effects is a Type I multiplier effect (see Miller and Blair, 2009). The impacts do not stop here, because with the direct and indirect effects it is expected that the level of income in the economy will increase as a result of increased employment. Some of this new income is spent on goods and services locally. This is termed an induced effect. Then the ratio between direct plus indirect plus induced effects and initial direct effects is termed a Type II multiplier. In the analysis that follows the focus is on the Type II multiplier effects associated with the operational spend of the managing contractor and subcontractors.

The modelling framework used to estimate the magnitude of these Type II indirect and induced effects was developed from the Input-Output tables for Wales (see Jones et al., 2010; Jones, 2022). These tables¹ provide a detailed and well-established economic map of the regional economy revealing flows of goods and services between industries, consumers and government. Importantly the framework allows an understanding of the complex financial relationships between regional industries. This framework then permits the effects of construction spending with regionally based suppliers to be traced along subsequent supply chains, with the multiplier then providing an estimate of *all* rounds of impact within the regional economy.² Input-Output tables remain a common frame of analysis (Havenga et al., 2022; Lee et al., 2022), providing a comprehensive overview of the indirect local economy effects of major construction projects which have been used extensively in Wales for related analysis (see Bryan et al., 1997; Jones et al., 2019; Morgan et al., 2017).

The modelling process involved the incorporation of spending connected to the road development within the Welsh Input-Output framework. The economic significance of purchasing activity connected to the road development for the economy could then be estimated using (Input-Output) multiplier analysis (see Miller and Blair, 2009). This relies on the use of standard Leontief-inverse multiplication to obtain the final regional production outputs necessary to meet the regional demand requirements supported by road development expenditures on suppliers and staff. This allows the estimation of regional impacts along potentially infinite rounds of supply-chain purchases. Then what follows is a modelled estimate of supply chain impacts arising from the identified supplier and staff expenditures. Fig. 1 provides a schematic representation of the methodology used for estimating the economic significance of the road development spending in Wales. It is important to recognise that the Input-Output analysis is unable to capture all the stimuli to the regional economy occurring through the in-process development, particularly here the expected improvements to labour markets and firm skills and abilities.

A mixed method approach was adopted to pick up on these types of

¹ The Input-Output (IO) table provides an 88 sector financial map of the Welsh economy. These sectors are detailed here: input-output-tables-2007-final-30-6.pdf (cardiff.ac.uk). The application of the modelling framework derived from the IO table is set out in Fig. 1.

² It is important to recognise here that the direct spend/output on which multiplier effects were estimated was based on the managing contractor plus their subcontractor spend. Any managing contractor or subcontractor spending that was identified as outside Wales was excluded from the analysis. However, there are inevitably other leakages from Wales, for example from household spending on imported goods and services. The multiplier impacts were based on estimates derived from the Welsh Input-Output framework. For the analysis the overall Type I Output multiplier was 1.40 and Type II 1.57. Similarly, the Type I Gross value added multiplier was 1.37 and the Type II was 1.59. Finally, the Type I employment multiplier was 1.43 and the Type II was 1.60.

effects. The Input-Output analysis was therefore supplemented by 17 case studies to unpack and evaluate the wider economic benefits from the contractors and sub-contractors' perspectives. This element of the research was designed and conducted in collaboration with industry partners, supporting a move toward stakeholder participation in research design and delivery (Macharis and Bernardini, 2015). Qualitative analysis is often overlooked when evaluating policy and practice surrounding transportation and transportation appraisals (Marsden and Reardon, 2017; Røe, 2000). The sample was identified through snowball sampling, with the lead contractors providing a list of recommended sub-contractors connected to the road improvement project. As the infrastructure project advanced, further referrals were provided by existing sub-contractors and suppliers. As such, case study participants were involved in the core operations needed to successfully prepare and implement the infrastructure project, including the provision of training, materials and operations. The case studies were developed through ongoing unstructured interviews undertaken with sub-contractors at periodic intervals during 2013–2021 (and here covering both Sections 2 and 3). To help assess the extent that the benefits continued in the aftermath of Section 2 construction and operations, a case study with a lead contractor was undertaken and analysed alongside the existing case studies to explore elements of legacy from the project.

The qualitative data collected allowed the researchers to attain evolving and incremental feedback from the sub-contractors, which was collated, mapped and analysed thematically. Categorical themes were identified and grouped across the case studies (Saldaña, 2021). Informal and unstructured interviews are a particularly useful method for pinpointing emerging themes and complementing the spending analysis. For example, key themes emerged in the cases illustrating instances of business and institutional benefits that were not captured in the spending analysis (or were precluded by limiting assumptions in the Input-Output approach), as well as effects more difficult to value in monetary terms. While unstructured and informal interviews are a common tool, it is important to consider the limitations of this approach, which includes a heightened threshold of researcher reflexivity to ensure that the researcher does not guide the directions of the findings (Mullings, 1999).

5. Findings

5.1. Direct and indirect regional economic effects

The cumulative economic impacts are first considered through the direct, indirect and induced impacts. The primary data were initially captured across ten six-monthly reports, and then a final report at the end of the project, which covered an extended time period to capture all remaining spending and activity for Section 2, from 2015 to 2021.

The in-process direct impacts for the region are measured by examining the estimated gross spending by sector, then deducting the spending from outside of Wales. Table 1 reveals that in the period 2015–2021, total spending was calculated at £325 m, of which around £222 m (68 percent) remained in Wales. A key issue here is the wide range of local sectors that benefit from the spending. A large proportion of the total and local spending was in the construction sector (just over £110 m in Wales). However, spending was also captured elsewhere, including renting of machinery and equipment, business and professional services and other manufacturing. The findings also point to variations in the spending retention by Welsh sector. For example, an estimated 85% of primary sector activity and 71% of business and professional service spending remained in the region.

The significance of the spending elsewhere in the economy outside of the construction sector is important. A large number of sectors directly benefit from the improvement scheme. In addition to providing accountability for public spending, in-process monitoring helped trace where spending is clustering in terms of sectors and places.

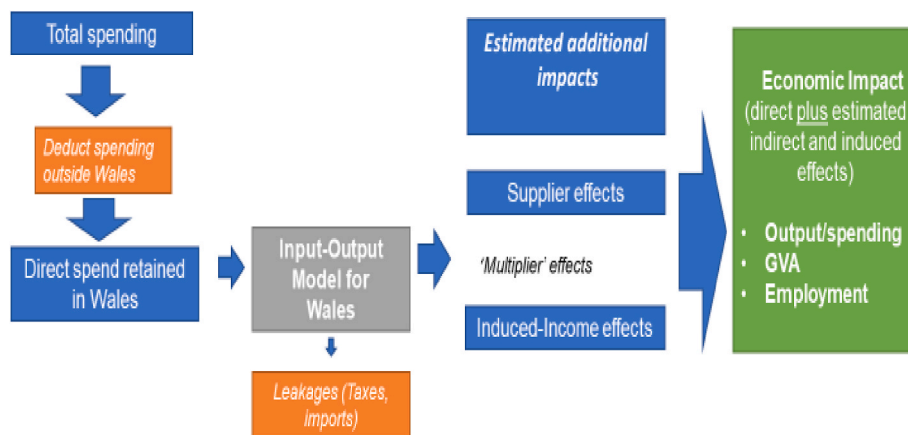


Fig. 1. Estimating economic impacts for the A465 using Input-Output Analysis.

Table 1
Estimated gross spending (output) by main sector/activities.

Sectors	Total £m	of which, in Wales £m	% spending in Wales
Primary/Extractive/Cement	28.1	23.8	85
Other manufacturing	29.3	12.5	43
Construction	156.3	110.1	70
Wholesale/retail/distribution	8.5	4.0	47
Renting of machinery and equipment	47.9	33.8	71
Business and professional services	50.3	35.9	71
Other services	4.6	1.7	37
Total	325.0	221.7	68

Note: Column totals may not sum due to rounding.

The wider impact is also important, with the £222 m of spending retained in Wales impacting local demand (through supplier effects and induced income effects explained in the previous section). The analysis reveals that this spending supported a further £127 m of activity in the regional economy, resulting in a total output effect (direct plus indirect and induced) of over £348 m. As Table 2 details, the total of direct, indirect and induced effects benefit a wide range of sectors with spillovers across the local economy.

The direct and indirect project impacts are also measured in terms of the gross value added (GVA) supported across the Welsh economy. Key components of GVA are income from employment and self-employment and company profits. Almost £179 million in GVA was supported across the Welsh economy by Section 2 road improvement project. Contributions to GVA are made across the local economy, but were most notable in construction, banking/finance and renting of machinery and

Table 2
Total impacts in Wales by sector.

	Output (£m)	GVA (£m)	Employment (FTE)
Primary/Extractive/Cement	30.9	12.4	250
Food/Textiles/Other Manufacturing/ Energy/Water	25.6	6.7	131
Metals/Machinery	11.6	3.7	59
Construction	135.0	77.5	2143
Wholesale/Retail/Distribution/Hotels	32.1	15.6	315
Banking/Finance/Renting of machinery and equipment	64.1	36.3	366
Other Business and Professional Services	42.1	23.0	361
Other Services	7.1	3.5	93
Total	348.5	178.7	3719

Note: Column totals may not sum due to rounding.

equipment, other business and professional services and wholesale/retail/distribution and hotels.

The labour market impacts are also quantified, accumulating to over 3700 FTE (full-time equivalent) person years of employment. As per the other metrics, the largest share is unsurprisingly located in the construction sector, providing more than 2140 FTE person years of employment. Employment is a common metric found within more recent appraisal approaches that are allowing for a wider set of dynamic effects (Atkins et al., 2017; Kelly et al., 2015; Melo et al., 2013).

5.2. Understanding wider in-process economic impacts

While the spending assessment reveals local economy and supply chain benefits as they develop, the qualitative cases provided a more fine-grained account and understanding of how in-process construction activity brought longer-term regional impacts. The 17 cases (C1–C17) informing the paper are summarised in Appendix 2. Three overarching themes are identified; namely the *development of ongoing stakeholder engagement and collaboration across the region; skill enhancement and portfolio building; business growth and expansion*. Together these strengthen the labour market, sectoral strengths and supply chain legacies of the project, but critically these outcomes evolved during the construction process and continued to be experienced after the implementation stage was complete (C17).

5.2.1 Engagement and collaboration across the region

The case studies identified the development of knowledge exchange networks between the managing contractor(s), local suppliers, sub-contractors, education providers (including Coleg Gwent College, Coleg y Cymoedd and Neath Port Talbot College), local authorities (e.g. Blaenau Gwent County Borough Council and Tredegar Town Council), Welsh Government, training bodies (i.e. Institute of Civil Engineers, Construction Industry Training Board (CITB)), and community stakeholders. The main contractor acted as an intermediary, managing interactions with local suppliers, subcontractors and the wider supply chain. While these provided short-term connections during construction, these engagement outcomes extend into longer-term benefits, with the development of knowledge exchange networks across local stakeholder groups. Knowledge spillovers included activities related to costing and successfully procuring additional work both on later Sections of the road improvement programme and within the local economy more broadly (C17). Multiple subcontractors detail the benefits of collaborative working. C14, for example, was involved in the planning and delivery of the geotechnical engineering services, working closely with the Welsh Government and its advisors. These close collaborations strengthened the company’s networking potential, improving future planning and longer-term strategic investment decisions. Additionally,

C13 developed their own strategic collaborations with prospective partners to prepare collective tendering for upcoming bids.

Subcontractors possessed differing levels of expertise, knowledge and existing connections. By working collectively long-standing networks developed by certain subcontractors could be shared. For example, C6 holds 30-years of experience delivering similar contracts and working directly with local authorities as well as South Wales Trunk Road Agency (SWTRA) and North & Mid Wales Trunk Road Agency (NWTRA)). During the programme, the main contractor encouraged these local suppliers to disseminate knowledge and share expertise to support other local businesses involved in the programme.

The findings confirm the heightened connectivity between groups of stakeholders who are linked, both directly and indirectly, to a large-scale infrastructure project through collaboration (Locatelli et al., 2017). An important component of connectivity relates to the collaborative activities between stakeholders, often focusing on the shared decision-making and collaborative activities when setting up the project. Examples include greater collaboration and focus on the local supply chain, working closely with key partners to decide on design and engineering technicalities, as well as involving local stakeholders in the development of local economic development aims. For Section 3, the main contractor established ‘Meet the Buyer’ events to maximise spend on the local supply chain, share information on local goods and services and provide local businesses with a route to tender for subcontracts. Similarly, for Section 2 ongoing engagement and events were central for the main contractors (C17), working with local partners and the community to coordinate technical specialities with local infrastructure use. By including these connectivity benefits in the in-process appraisals a more holistic understanding of how early collaboration can help stakeholders when sharing resources, mitigating risk, disseminating knowledge and expertise, and building wider networks across the supply chain is achieved.

5.2.2 Skill enhancement and portfolio building

The road building programme provided extensive training and development opportunities for the local labour market. The most pronounced outcome is that of skill enhancement through experience, expertise and accreditations. A central provision provided during the development and construction phase is that of apprenticeships and onsite vocational training. The main contractor and its suppliers worked with the CITB and Welsh Government to establish a National Skills for Construction Academy. The four-year initiative supported the upskilling of the workforce and contributed to reducing local unemployment.

In relation to Section 2 of the A465 improvements, the main contractor, along with its suppliers and subcontractors offered 69 apprenticeships to young people in South Wales, providing accreditation for engineering, surveying, accounting, groundwork and managerial roles. In addition to the apprenticeships, the project facilitated 18 graduate opportunities and 120 work experience opportunities. The CITB also facilitated collaboration across local education providers (e.g. Coleg Gwent, Coleg y Cymoedd and Bridgend College) and local authorities (including Neath Port Talbot Council and Bridgend County Borough Council). The initiative encompassed 171 educational site visits, 290 school support activity days, 381 training courses and over 16,700 h in training. While these training opportunities pertain to the programme, the longer-term effects in terms of upskilling and future employment opportunities were seen as important developmentally and with links to later stages (Section 5 and 6) of the A465 improvement process (C17).

Bespoke schemes were established to improve employability skills and provide necessary skills for unemployed people in local areas. For example, a construction taster programme was created with the support of the Welsh Government’s ‘LIFT’ programme (aligned to Welsh Government’s (2013) Tackling Poverty Action Plan to address worklessness) aimed at encouraging young and unemployed people to ‘get into construction’. The programme provided work placements and employment

along the A465 site, offering practical experience enhanced through Continuing Professional Development (CPD) accreditation. Additionally, schemes were created that encouraged inclusivity among the workforce. The Chwarae Teg and Agile Nation 2 Programme encouraged more females to take-up leadership and management roles, with over 20 main contractor employees utilising the opportunity.

A further nation-wide Welsh Apprenticeship Alliance between the Welsh Government, contractors and the Institute of Civil Engineers was created in 2017. An underlying premise of the alliance was the provision of engineering degrees for those facing barriers to higher education. The scheme gained around 25 apprenticeships annually, undertaking six-years of part-time learning while working on projects, including the A465 improvements. The alliance encompassed a range of operational and strategic tasks, involving working with employers to undertake apprenticeship reviews, facilitating educational providers, networking with the local community and businesses, and providing collaboration and dissemination opportunities for apprenticeship holders. The scheme received a number of national awards, including the ICE President Medal and the Construction Investing in Talent ‘Corporate Responsibility Scheme of the Year Award 2017.’

Additionally, the work programme provided onsite employment on a complex, long-term and high-profile project. With these short-term labour market gains longer-term socio-economic impacts emerge, including enhancements to employability and experience attained through ongoing onsite training and operations (C17). The workers in C10 gained specialist plant experience for the construction of culverts, bridges and retaining walls. From this experience, the company was able to provide bespoke training for similar work from their south Wales location. Moreover, in the case of C11, the A465 contract provided 80 weeks of job security for over 100 workers from Merthyr and Ebbw Vale. These individuals, as a result of their work on the project, were able to strengthen their work histories when applying for work on subsequent sections of the road, and on other projects. As such, the short-term benefits build longer-term legacy.

5.2.3 Business growth and expansion

The case studies highlight the benefits for businesses collaborating on a major construction project which were particularly prevalent for micro/small-to-medium enterprises (SMEs) (C17). The provision of long-term funding and experience on a complex project was stated to benefit the local firm’s ability to develop and expand. Some case study participants had been involved in Section 3, before continuing onto Section 2, and have now been appointed to more specialist roles on Sections 5 and 6 (C17). C9 worked across both Sections providing temporary and permanent fencing, extending their experience and professional accreditations, including BALI (British Association of Landscaping Industries) membership and highways sector scheme approval (ISO 9001). The business increased in scale and scope, employing many workers who were previously unemployed.

In relation to Section 2, SMEs revealed business value in being able to work on what is a geologically complex project, and with this experience transferring through to future projects. C16 worked on projects mostly in England, including the London Hammersmith Flyover. Their trained workforce was subsequently able to put their skills to work on varied sub-contractor packages on the A465 Section 2 works. These activities supported a Welsh Fast Growth firm award. The case studies therefore outline the benefits attained in terms of the development of expertise in engaging with large scale procurement processes. The experiences and skills gained contributed to the companies securing other contracts.

These in-process impacts on suppliers and subcontractors are a potential means of improving the productivity of the local collaborating firms (and with links here to skills development described in the previous sub section). The local authority areas through which the A465 passes are characterised by relatively poor productivity levels (typically revealed in levels of gross value added per head over 30% below the UK average) and with this connected to the loss of relatively productive

manufacturing industries, together with low specialisation in faster growing industries. Prior research has also argued that an element of the productivity problem in Wales links to the relatively low number of SMEs identified as having high growth prospects, with this entailing low rates of business evolution from small into medium-sized firms ([Economic Intelligence Wales, 2019](#)). While these productivity differences have proven to be persistent, the case evidence in this paper suggests that infrastructure development and resulting innovation between managing contractors and their local suppliers (particularly SME suppliers) and the new growth opportunities that arise, could play a role in improving productivity growth. The wider effects identified in this paper suggest that the total regional gains resulting from the infrastructure development will exceed those direct and indirect impacts estimated in the previous section.

6. Discussion

It was argued at the outset that transport appraisal approaches typically focus on end user benefits of new or improved infrastructure or provide a snapshot of expected or actual gains in the periods leading up to, and after, the project's construction stage. However, this paper argues for closer monitoring of in-process benefits. While the monitoring outlined in the paper primarily provided a longitudinal tracking of impacts to the local economy, in particular focusing on labour market gains, sectoral support and supply chain legacies, these gains may not be merely short term, temporarily transferred from another area or obscured by externalities ([Laird and Venables, 2017](#); [SACTRA, 1999](#)). Instead, these in-process economic gains contribute to longer-term regional economic development that is particularly pertinent for lagging regions. In the A465 case, evidence of benefits dispersing across the economy was found, from a spillover of output and GVA gains that can spur productivity, through to labour market benefits, an upskilling of the labour force and the development of sustainable collaborations along supply chains and across sectors.

In practical terms socio-economic outcomes in road transport appraisal processes remain undervalued ([Atkins et al., 2017](#)) and largely overlook the in-process benefits ([Laird and Venables, 2017](#)). While cost-benefit analysis *ex ante* and *ex post* remain important it is often too procedural ([Kelly et al., 2015](#); [Odeck and Kjerkreit, 2019](#)), disconnected from supply side improvements ([Mullen and Marsden, 2015](#)), affected by optimism bias ([Flyvbjerg, 2007, 2009](#)) and with a challenge to connect it with in-process analysis. While studies might focus on the comparison between *ex ante* and *ex post* analyses (see [Kelly et al., 2015](#)) the explicit consideration of in-process benefits is often omitted. Moreover, the scarcity of in-process evaluations creates mistrust over accountability, with a potential for those possessing knowledge of the system to maximise the gaps in the appraisal process and highlight only the favourable outcomes ([Flyvbjerg et al., 2016](#)). Incorporating periodic reviews during the lifetime of the infrastructure projects provides greater transparency, allows for in-process comparisons to be made with similar infrastructure projects and incorporates real-time reporting from sources directly impacted by the project. By more fully connecting *ex ante* claims with *ex post* outcomes, in-process reporting may help to reduce the tendency towards 'survival of the unfittest' in terms of future infrastructure projects.

Despite scepticism over the construction sector's low-value properties and propensity to market volatility ([Angulo et al., 2018](#); [Lagravinese, 2015](#)), this paper points to the overlooked benefits of long-term infrastructure projects when building sectoral specialisation and structure of the region. Potential benefits can be realised by monitoring and building on the socio-economic benefits during the in-process stage and supporting these benefits into the *ex post* stage. This study points to the advancements of wider economic gains during the course of the construction and operations phases (i.e., design, development, build and handover), establishing collaborations, expertise and expansion opportunities that transcend the life of the project itself. While the completed

infrastructure is seen to provide productivity and competitiveness benefits ([Love et al., 2016](#); [Mullen and Marsden, 2015](#)) this paper highlights the importance of the 'in-process' activities for augmenting existing sectoral and labour market components, therefore helping to support lagging economies.

The mixed methods analysis and periodic design of the analysis captured the accumulating effects in real time, monitoring how these expand across the time-horizon (seven years) studied and identifying legacy effects for regions and the businesses and workers within them. The method then facilitated the identification of the wider regional gains that cannot be fully captured though the quantitative modelled impact analysis. This paper begins to demonstrate that monitoring developments provides a better understanding of how, and to what extent, transportation schemes can bring more unexpected benefits. The process by which lessons and competencies are collaboratively attained, shared and fostered may help to support the development of indirect knowledge spillovers across the local economy ([Steen and Hansen, 2014](#); [Qui et al., 2017](#)). As the findings from this study also suggest, these knowledge spillovers bring with them opportunities for longer-term incremental innovation for firms across the local supply chain ([Hervas-Oliver et al., 2019](#); [McCann and Simonen, 2005](#); [Morrissey and Cummins, 2016](#)). This study then contributes to an overlooked aspect of transport planning and policy, illustrating how the in-process operations and construction activities can encourage and embed subsequent and longer-term socio-economic outcomes for regions.

The case considered in this paper also illustrates that systematically monitoring socio-economic impacts during the course of a development ensures greater transparency ([Flyvbjerg et al., 2016](#); [Penyalver et al., 2019](#)), identification of potentially additional economic outcomes, accountability and continuity in measurement of outcomes. This would facilitate an orderly progression towards the factors that might also be considered in the *ex post* analysis of wider user benefits of the new infrastructure.

7. Limitations and future research

The paper is not without some limitations. For example, while it addresses potential localised externalities advanced during the in-process operations and activities, there is still scope for follow-up research to more fully understand how these network and innovative gains might vary depending on firm and regional characteristics. Moreover, the specific Welsh policy context towards the encouragement of in-process benefits may restrict generalisation of the findings to other places.

It is also noted that the economic modelling framework has limitations, not least in terms of embracing changes to the supply side of the economy caused by the road development process. Aside from the standard assumptions, the analysis also took no account of the nature of project financing and its source, and that impacts may vary according to the procurement model adopted. The Input-Output framework does not identify opportunity costs associated with the public spending. To redress these types of problems and better understand the complex regional effects associated with construction shock, displacement and financing variations, a computable general equilibrium model would be a more appropriate methodological tool ([Kim et al., 2011](#); [Rokicki et al., 2021](#)). However, while the limitations to the Input-Output model are accepted, this paper does use a combination of data sources and cases to support and unpack claims, combining a focus on the periodic assessment of economic benefits understood through the framework of an economic model but then supported and supplemented through qualitative case studies. In doing so, the paper reveals that a better understanding and structuring of in-process benefits of infrastructure improvements is important for a more holistic appraisal of impact.

There is a final question on the extent to which the effects described in this paper apply to other major infrastructure projects in Wales (and elsewhere). The effects and issues discussed in the paper are considered

to be relevant to other infrastructure sectors in the local economy, particularly those where there is scope for relatively high levels of local content. One illustrative case is renewables infrastructure in Wales, where comparatively high levels of development spending in more remote locations appear to have not necessarily led to legacy or significant local socio-economic outcomes during the construction stage. This may be one reason why development spending across renewables projects in Wales has often been twinned with explicit and generous community benefit requirements (see for example Jones et al., 2019; Bristow et al., 2012). In such cases, a clearer identification of in-process outcomes would fill important information gaps.

Author statement

Max Munday: Formal analysis; Methodology; Roles/Writing - original draft; Writing - review & editing; Funding acquisition; Investigation, Case development, **Laura Reynolds:** Conceptualization; Formal analysis; Methodology; Roles/Writing - original draft; Writing - review & editing, **Annette Roberts:** Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Roles/Writing - original draft; Writing - review & editing.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

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