Welsh Government

The Impact of the Severn Tolls on the Welsh Economy

Final Report

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Background

The Severn Crossings are the primary gateway to South Wales, catering for average daily traffic of around 80,000 vehicles. The first Severn Bridge was opened to traffic in 1966. The Second Severn Crossing was opened in 1996 and the two bridges now operate in tandem. Tolls have been in place for the entire history of the Severn Crossings and, as with most toll bridges around the world, the charges have been used to pay for their construction, maintenance and operation through a concession agreement with a private operator.

The concession agreement currently in place ends at the point that the operator has collected £996m in 1989 prices. Recent estimates have suggested that this point could be reached by around 2017. Following the end of the concession agreement, ownership (as well as the future maintenance burden) will transfer back to the UK Government. This offers the opportunity to consider the possible implications of alternatives to the current user charging regime on the Severn Crossings.

In December of 2010, the report of the Welsh Affairs Committee enquiry into the Severn Crossings Toll was published. One of the main findings of the Committee was the lack of robust evidence for the impact of the tolls. This study, commissioned by the Welsh Government and undertaken by Arup and the University of the West of England (UWE), is the first comprehensive assessment of the impact of the tolls on the Severn Crossings.

Study Approach

The complex relationship between the Severn Crossings and the Welsh economy is such that the study covers a broad range of transport and economic issues. The terms of reference for the study are to assess the impact of the tolls on the Severn Crossings in relation to traffic patterns, the environment, impacts on consumers and businesses, effects on the labour market, influences on business location and the impacts on overall economic performance of South Wales, and the comparative effects on the South West of England.

The study employs a number of scenarios to consider the potential impact of a range of alternative tolling regimes were they to be introduced after 2017. For simplicity three different scenarios were chosen, each of which have been compared against a 'do minimum' scenario under which the tolls are assumed to remain unchanged (in real terms[1]) from current levels:

- *Scenario 1 – Reduce tolls on both bridges by 50%;*
- *Scenario 2 – Remove tolls from the Severn Crossings, and;*
- *Scenario 3 – Increase tolls on both bridges by 50%.*

[1] This is equivalent to the current arrangement under the concession agreement whereby toll prices are adjusted at the start of each year *'by the same percentage as the percentage difference between the retail prices index for March 1989 and the retail prices index for the month of September immediately preceding the making of the order'*. (Severn Bridges Act 1992, http://www.legislation.gov.uk/ukpga/1992/3/section/9). The adjustment is rounded to the nearest 10 pence.

The scenarios are intended to examine the potential effects of toll removal or reduction. An equivalent increase in the toll has also been used to explore the symmetry or otherwise of the effect of an increase or decrease in the toll. All of the scenarios are highly simplified and none of the scenarios are intended to represent policy proposals.

Given that the level of the toll has remained unchanged (in *real terms*) over the past decade (since the tolls are adjusted in line with inflation), the study is unable to draw conclusions from historical changes in the toll on the Severn Crossing. Therefore, the conclusions of the assessment are based on what we can infer from existing patterns of behaviour, on secondary evidence, and through modelled transport behaviour and economic impacts building on logical and evidence based assumptions. The following research and analysis was undertaken:

- A literature review of the impact of road tolls, including tolled bridges, elsewhere;
- High-level traffic and transport modelling;
- A survey of businesses in South Wales and the South West of England;
- In depth interviews with a selection of businesses and representative groups;
- A survey of consumers in the South West of England, and;
- Modelling of the effects of tolling on productivity.

Severn Crossings Traffic and Travel Patterns

Based on two-way vehicle count data, since 2003 there has been steady growth in traffic across the M4 Second Severn Crossing, with an average annual growth over the period of 1.78%, compared with 0.63% across the UK motorway network. In 2008, in terms of Annual Average Daily Traffic (AADT)[2], 61,455 vehicles crossed the M4 Second Severn Crossing per day and 17,772 crossed the M48 Severn Crossing per day. The M48 carries more local traffic with the majority of origins / destinations being Monmouthshire, Bristol and the South West of England, whilst the M4 is more strategic in nature serving a much wider market, with origins and destinations from across all areas of South Wales and across Southern England.

There is a small directional imbalance, with 4.7% more traffic in the eastbound direction compared with the westbound direction. This is due to the fact that the toll is charged only in the westbound direction and therefore a small proportion of traffic crossing uses an alternative route to make the westbound trip (via Gloucester).

Direct Costs of the Severn Tolls

In 2011, the cost of the toll stood at £5.70 per car, or £11.50 for small buses and for goods vehicles of up to 3.5 tonnes and £17.20 for heavy vehicles in excess of 3.5 tonnes. As noted, the toll is adjusted in line with the Retail Price Index. Since 2000, growth of nominal GVA per capita and wages in Wales slightly exceeded the rate of growth of the toll price until the recession which started in 2008. Over the period 2000 to 2010, the toll is largely unchanged relative to GVA per capita and wages. Growth in fuel costs, vehicle maintenance costs and vehicle tax and

[2] The number of vehicle travelling in both directions per day, averaged over the year, taken from automatic vehicle count data provided by Traffic Wales.

insurance costs have significantly exceeded growth in the price of the toll. However, vehicle purchase costs have fallen since 2000 such that total 'motoring expenditure' inflation has risen slower than the price of the toll.

The toll increases the cost of journeys between South Wales and parts of the South and South West of England. It is useful to place the cost of the toll in the context of total journey costs, taking into account fuel costs, vehicle maintenance and depreciation costs as well as the opportunity cost of time spent travelling. Average costs and 'values of time' for different road users are provided by the Department for Transport for this purpose.

The proportion of trip costs accounted for by the toll varies greatly across different types of user. For a car journey (excluding commuters and business travel) the toll represents approximately 19% of trip costs for a journey between Cardiff and Bristol[3]. For a business traveller, considering the value of lost productive time, toll costs fall to approximately 8% of trip costs. For goods vehicles making the equivalent journey, tolls represent 23% of total journey costs for a light goods vehicle and 21% for a heavy goods vehicle. The proportionate impact of the toll falls with distance travelled.

Annual Toll Costs

Total revenue from the tolls (both crossings combined) in 2010 amounted to £76m. Taking all goods vehicles toll payments and toll payments of business users, the direct toll costs imposed on businesses can be roughly estimated to be £47m (excluding VAT) in 2009 prices, with remaining £34m (including VAT) being paid by consumers. Therefore the total cost to businesses and consumers, once VAT is taken into account, is in excess of £80m a year.

There are further direct costs imposed by the toll due to the time related costs of the stop-start delay at the toll booths and the impact on drivers taking alternative routes and therefore experiencing longer journey times and costs. The latter appears (based on the small directional imbalance) to make up a relatively small proportion of trips.

Conversely, tolls and user charges are often associated with having congestion relieving effects which serve to reduce congestion and improve journey times for other users who are willing to pay tolls. Whilst this is not a major factor for the Severn Crossings (given that the Crossings themselves operate well within capacity), traffic modelling suggests that the tolls are likely to have a minor positive effect on traffic flows elsewhere on the network.

There is no data available which allows an accurate assessment of how these costs are split between vehicles and businesses based in Wales, or elsewhere. Given that it is likely that there is some 'cost pass through' or sharing of toll costs between the toll payer and the end customer this is highly complex. In either case (excluding the significance of through journeys to or from Ireland) the tolls represent a cost imposed on economic transactions between South Wales and the South and West of England.

[3] Based on the Cardiff to Bristol leg of a return trip assuming half the toll cost applies to each leg, under average morning peak conditions.

Impacts on Traffic and Transport

Evidence from Toll Roads Elsewhere

Empirical evidence on the elasticity of demand[4] with respect to road tolls is limited because of the relative scarcity of toll roads and crossings worldwide, as well as the lack of ex-post assessment following the introduction or removal of tolls. In general, toll elasticities in existing studies tend to be based on the introduction of a toll or an increase in the level of a toll.

The elasticity of demand with respect to a toll is highly dependent on a range of local and contextual factors. In general, available evidence suggests that transport demand is relatively inelastic to toll price, with toll price elasticities typically lying within the range -0.1 to -0.5[5]. A key determinant of the elasticity of demand is the availability of an alternative, untolled route although there are many other factors. Given the travel distance required to avoid the Severn Crossings for most journeys between England and Wales, it may be reasonable to assume that the price elasticity of demand for the Severn Crossings is probably towards the lower end of this range.

As with transport effects, a review of the literature on the economic effects of toll roads highlights the difficulty of applying experience from elsewhere given the strong influence of local and contextual factors. There are a number of ex-ante studies which have considered what might happen should a toll be removed, although this study was not able to identify any applicable evidence of the impact on local or regional economies from studies undertaken following a change in a tolling regime.

Modelling the Effects of Traffic and Transport

As noted, because tolls have been in place since their opening, there is no reliable historical change in tolling regime on which to base an estimate of the effect of tolling on traffic demand. Furthermore, the lack of a comprehensive literature on toll responses, and the importance of locally specific factors, is such that the most appropriate approach to analysing each of the toll scenarios is a modelled approach.

The M4 traffic model was used for this purpose given its status as the primary traffic model covering the Severn Crossings. The 'core area' of this traffic model covers the strategic highway network in South East Wales to a high level of detail, with the broader coverage extending into parts of the South West of England. The current (2010) and future year model were updated to reflect changes in traffic flows across the bridges since 2005 using count data provided by Traffic Wales.

[4] In economics, an elasticity measures how a change in one variable affects another. In this case, the elasticity of demand with respect to the toll refers to the sensitivity of demand for travel on a tolled road to changes in the prices of the toll. Price elasticity (point elasticity) is measured as the ratio of the percentage change in demand to the percentage change in the price. A negative elasticity typically occurs because demand is inversely correlated with price.

[5] Demand is considered to be *inelastic* if the change in demand is less than proportional to the change in price (ie. the elasticity is between 0 and 1 or 0 and -1). Given that tolls make up a proportion of total journey costs, this does not necessarily imply that overall transport demand is inelastic to total transport costs.

A high level traffic analysis was undertaken for each of the scenarios for the years 2018, 2023 and 2028. These provide approximate estimates of changes in traffic flows based on the modelling.

The headline results under each scenario show that reducing the tolls by 50% would result in an estimated increase in total traffic (as against a 'do minimum' scenario similar to the existing toll charges) in the order of 5% based on predicted conditions in 2018. Removing the tolls entirely (as well as eliminating any toll collection delay[6]) would result in an estimated increase in traffic across of 12%. This is equivalent to around 11,000 vehicles per day. An increase in the toll of 50% is estimated to reduce traffic by nearly 5%. In reality, traffic responses are dynamic and users' behaviour will adjust over time, whilst the traffic model is effectively static. It should be noted that the estimated traffic responses to the each of the tolling scenarios outlined above are, in effect, long run responses to changes in toll.

Generally, under average conditions, the increase in traffic under the toll removal scenario would be expected to result in marginal changes in traffic flow and speed. However, the scenarios do highlight potentially more significant effects at the Brynglas tunnels where capacity is already constrained. A more detailed assessment of forecast traffic impacts under varying traffic conditions would be required before firm conclusions can be drawn on the effects on congestion more generally. The analysis also shows that reducing or removing the tolls would result in a permanent increase in carbon emissions, although removing the stop-start delay at the toll booth would have some offsetting effect. The magnitude of the change would probably be small in comparison with total emissions from transport in Wales.

The above changes in traffic demand have been applied to recent data on SRC plc toll revenue in order to understand the financial implications of the scenarios[7]. Total revenue in 2009 was £77.4m. The *reduction* in revenue if the toll were halved is estimated to be approximately £36m per annum (2009 prices), a 46% reduction. An increase in the toll of 50% would result in *additional* revenue of around £36m per annum, a 41% increase. In each case, the change in revenue is less than proportional to the change in toll because of the offsetting effect of higher or lower traffic flows.

Impacts on Business Performance and Location

Based on the responses from the business survey as well as evidence drawn from more in depth interviews, an analysis was undertaken of the impacts of the Severn Crossing on the performance, behaviour and competitiveness of business in South Wales.

[6] The delay experienced by users at the toll booth is likely to vary greatly across the day/week/year. It has only been possible to employ a rudimentary approach to incorporating the effects of toll booth delay based on observations undertaken in the spring of 2007.

[7] Estimated changes in toll levels and traffic flows have been applied to the latest available data on Severn Crossing revenue from 2009 taken from SRC plc Annual Reports. The analysis assumes that SRC plc revenue is unchanged in real terms from 2009 and ignores the effect of changes in demand between 2009 and 2018.

Business Costs and Performance

The research confirms the importance of the Severn Crossings for businesses in South Wales. Of those businesses surveyed, 50% considered the crossings to be either 'important' or 'very important' for their business. The proportion of businesses for which the tolls are 'significant' is a substantial minority, with 12% reporting the tolls to be significant and 8% reporting the tolls are highly significant. The importance placed on the tolls was closely related to the particular sector, location and operating structure of the firm in question. Not unexpectedly, businesses based in South Wales are more likely to place importance on the crossings and the tolls than businesses based in the South West of England.

The significance of toll costs, however, must be seen in the context of overall operating costs. For the vast majority of businesses direct toll costs represent a very small proportion of total costs. For the service sector and 'high value' manufacturing firms, transport costs typically make up a small proportion of overall costs and therefore toll charges are of diminishing importance.

The exception is transport and logistics businesses predominantly engaged in trade between the South and West of England and South Wales. Evidence provided to the Welsh Affairs Committee, as well as media reports[8], suggests that, at the highest end, a small number of businesses spend in excess of £200,000 per year on tolls. This was supported by consultations with representatives of freight operators. An illustrative analysis suggests that toll costs could, in the most extreme cases amount to between 5% and 10% of annual vehicle operating costs[9] for freight vehicles. Given that profit margins tend to be relatively low in this sector, the implications for business performance and profitability can be significant where a firm is predominantly engaged in 'cross-Severn' goods transport.

Business Location and Markets

It should be considered that the tolls could be expected to deter competition in local markets as well as providing a barrier for Welsh businesses when competing in England, although the relative size of the two markets is such that any 'barrier to trade' is likely to be felt more keenly by business in South Wales. Based on the analysis of the survey responses, businesses were more likely to report that tolls affected their cost base and profitability than they were to suggest that the tolls deter customers or place their business at a disadvantage, in comparison with businesses located in England, when competing in particular markets.

Within the logistics sector, there is some evidence of businesses being encouraged by toll costs to locate vehicles at depots in England rather than in South Wales, although for the most part freight businesses are likely to be engaged in movements involving either a Welsh pick up or drop off for which any operator, whether based in England or South Wales, would be subject to the toll.

Where toll costs are significant for businesses, tolls effectively increase the cost of doing business in South Wales, thereby making South Wales a less attractive location for investment. Location decisions are highly complex and businesses

[8] http://www.bbc.co.uk/news/uk-wales-11719614

[9] Vehicle operating costs includes fuel costs, vehicle operating costs, wages, overheads and other costs such as vehicle licensing.

will consider access to markets, access to skills, wage costs, costs of land and property. More generally, evidence from the business survey suggests that the quality of existing transport links (quality of access to motorways, local road network, public transport, and parking) are seen as a key advantage of firms' current location. When asked about the main disadvantages of their location, transport related factors were also frequently identified by Welsh firms. The Severn tolls were specifically noted by one firm to be a disadvantage without being prompted.

As with previous reports into the tolls, whilst it was established that some businesses pay regard to toll costs when considering locations in South Wales, no instances could be identified where toll costs were pivotal in a decision not to locate in South Wales. In the specific case of Regional Distribution Centres (RDCs), when choosing a location it is typical to undertake a detailed cost-benefit assessment of potential locations which takes into account all operating costs including tolls. On this basis, it is possible to imagine a situation in which the tolls contribute to a decision to locate outside South Wales. However, given the wage and fuel costs associated with journeys across the estuary notwithstanding the tolls, in most cases proximity (to the M5 corridor for example) is likely to be a more significant factor than the tolls themselves.

Impacts on the retail, tourism and leisure sectors

The study has considered whether the cost imposed on consumers by the toll deters visitors to Wales, thereby having a negative effect on the tourism or retail sectors. As with tolls and business location, the significance of the tolls in determining visitor's travel decisions should be seen in the context of total trip costs. From this perspective, toll costs are likely to be significant mainly for trips of a short duration, such as day trips and shopping trips, and where the distances travelled are relatively short. For longer distance trips and overnight stays, the toll is likely to be a small proportion of the total costs of a visit. Therefore, 'higher value' tourism is less likely to be affected.

A survey of households in South West England was undertaken to help better understand the impact of the tolls on the perceptions of potential visitors to Wales. When asked if they would expect to make more trips to Wales by car if the Severn tolls are removed, 22% of surveyed residents of South West England said they would expect to make more trips to Wales in the next twelve months. Whilst survey responses of this nature are potentially subject to bias, the results might suggest that removing tolls would encourage more visits to Wales. Notably, the proportion of respondents expressing this view falls with distance from the crossings, perhaps supporting the assertion above that tolls are more likely to influence trips of a shorter duration.

It should, however, be considered that the tolls might be expected to deter trips in either direction. Therefore, the net effect on the Welsh visitor economy could be positive or negative. Given the importance of the visitor economy in Wales and the increasing importance of Cardiff as a retail destination (relative to Bristol for example), it is considered likely that the net effect of the tolls is, on balance, negative.

A further consideration, raised by tourism industry representatives, is whether toll negatively affects the way people *perceive* Wales as a visitor destination and whether this has an effect disproportionate to the financial cost of the toll. For

example, the cost and inconvenience of the toll were highlighted as potential issues during the 2010 Ryder Cup when tourism bodies were seeking to encourage return visits. However, effects on perceptions are difficult to measure or to separate from other factors and there is no firm evidence on the link between tolls, perceptions and propensity to holiday in Wales.

Impacts on the Labour Market

Based on the current toll cost of £5.70 per vehicle, a simple analysis would suggest that toll costs for a commuter crossing the Severn each working day would amount to around £1,400 over a year[10]. For a commuter trip between Newport and Bristol, the toll accounts for approximately one quarter of total journey costs. As such, the tolls represent a potentially significant deterrent to commuting between South Wales and the South East of England.

Evidence from the 2001 census showed around 6,600 workers commuting from the 'Welsh Severnside[11]' area to the 'English Severnside[12]' with a further 8,500 travelling to work in other parts of England. There is a directional imbalance in commuting across the Severn with around 2,000 commuters travelling in the opposite direction from the English Severnside to the Welsh Severnside. It should be noted that a proportion of these commuters are likely to travel by other modes or take alternative routes to the crossings. Traffic model data suggests that there are around 12,000 return trips across the bridges made by drivers reporting that they are travelling to work, although the relationship between this number and numbers of commuters or jobs filled is not necessarily direct.

The traffic analysis suggested that removing the tolls would result in an increase in commuting across the Severn Crossings of 11% (excluding reassignment of traffic). Changes in commuting patterns will take time to play out and this should be considered a long term adjustment. This degree of change could represent upward of 1,000 commuters. However, this result is based on general observation of transport user behaviour and is a relatively crude measure. Local labour markets are complex and individuals typically make their commuting decisions based on a range of factors. Mobility, recruitment and job search geographies vary by sector and by occupation. Individuals typically make their commuting decisions based on the balance of wage and job differentials between home and work locations, differences in the cost of living / quality of life and the costs of mobility.

Some inferences can be made based on the existing profile of commuters. Firstly, the existing directional imbalance and the differential in wage rates between the 'English Severnside' and the 'Welsh Severnside' might suggest the greatest part of any increase in commuting would relate to residents of Wales travelling to jobs in England. This effect could be reinforced by patterns of migration with more affordable house prices in Wales and the rural amenity of an area such as Monmouthshire which currently has the highest number of commuters into England of the South Wales Local Authorities.

[10] Based on one crossing for each working day – 240 crossings at £5.70 gives £1,368.
[11] The 'Severnside' area has been defined in order to broadly reflect normal commuting distances. Welsh Severnside includes Cardiff, Newport, Monmouthshire, Caerphilly, and Torfaen.
[12] English Severnside includes Bath and North East Somerset, the City of Bristol, North Somerset, South Gloucestershire, and Stroud.

Secondly, given the occupational profile of commuters and the fact that higher paid workers are typically more mobile than lower paid workers, it is likely that additional commuters will also be above average in terms of pay and skill levels. The inference from this is that the additional commuting is likely to primarily represent changing employment search areas or changing distribution of employment rather than any increase in participation rates.

Effects on Productivity

Exploratory economic modelling techniques have been employed to attempt to quantify the overall impact of the Severn tolls on the performance of the South Wales economy. The analysis is intended to supplement the survey and other approaches through reference to statistical data on the relative performance of firms in Wales and England. The analysis builds on previous studies into the relationship between accessibility (broadly, proximity to economic mass) and economic performance. The approach taken is to estimate the extent to which differences in economic performance (in this case measured as productivity) can be explained by spatial factors that are in turn influenced by transport costs (including toll charges). Given that there is significant uncertainty in the results provided, the precise estimates provided are intended to be illustrative and should be interpreted with caution.

A peripherality variable has been constructed based on the cost of travel between all areas in the model. The research finds a statistically significant relationship between this measure of peripherality and firm productivity. The model indicates that a 1% reduction in peripherality would lead to an increase in productivity of 0.033%.

The peripherality variable has subsequently been adjusted to reflect conditions if the toll were to be removed after 2018. The impact of toll changes becomes more marked the closer the area is to the crossings. The results suggest that, based on the peripherality-productivity relationship, the tentative conclusion of the economic modelling exercise is that removing the tolls would boost productivity by in the order of 0.48% which would translate to an increase in the annual Gross Value Added (GVA) of South Wales of around £107m. This compared with 'direct' effects (reduced transport costs – i.e. toll payments) of some £80m giving a potential 'multiplier' of around 1.3. The results indicate that the indirect effects discussed elsewhere in this report are such that the overall impact of the toll exceeds the direct cost of the toll. However, caution should be applied in drawing precise conclusions the magnitude of GVA impacts through economic modelling techniques.

Conclusion

This study is the first comprehensive attempt to consider the effects of alternative futures for the tolls on the Severn Crossings. The study has highlighted the many complex impacts and issues related to Severn tolls. The tolls impose a cost on users of the Severn Crossings and therefore much on the analysis has focussed on the degree to which the tolls impact negatively on the economy. It is clear that such impacts are not evenly distributed across individuals, sectors or geography. The study has not attempted to consider the potential trade-offs or opportunities associated with re-investment of toll revenue following the end of the concession agreement. Furthermore, whilst the research has tested some relatively simple scenarios for the future of the tolls it has also highlighted interesting opportunities

relating to alternative approaches to tolling – such as the level of toll for different vehicle types, discounts for regular use, variable tolls and new technology – which could mitigate against some of the negative impacts highlighted in this report.

1 Introduction

1.1 Background

The Severn Crossings are the primary gateway to South Wales, catering for daily traffic flows of around 80,000 vehicles. The first Severn Bridge was opened to traffic in 1966. Over time, growth in traffic led to issues of congestion on the bridge which, compounded by the effect of frequent closures due to high winds, led to the requirement for a second crossing. The Second Severn Crossing was opened in 1996 and the two bridges now operate in tandem.

Tolls have been in place for the entire history of the Severn Crossings and, as with most toll bridges around the world, the charges have been used to pay for their construction. A private company, Severn River Crossings plc (SRC plc), is responsible for the ownership and management of both bridges under a Concession Agreement entered into by the UK Government in 1992. The Concession Agreement ends at the point that SRC plc has collected £996m in toll revenue in 1989 prices. Recent estimates have suggested that this point could be reached by 2017[13].

Following the end of the Concession Arrangement, ownership (as well as the future maintenance burden) will transfer back to the UK Government. This offers the opportunity to consider alternative approaches to user charging on the Severn Crossings. The future of the tolls on the Severn Crossings is likely to be the subject of increasing debate as the end of the Concession Agreement approaches.

1.2 The Severn Crossings and the Welsh Economy

New transport infrastructure is often justified, not just on the benefits experienced by users, but on the predicted effects on the local or regional economy. The argument follows that better transport and improved accessibility can have *spill over* effects which result in more competition, improved productivity or higher employment.

The relationship between transport infrastructure and economic performance is complex and the importance of transport links in stimulating economic development is contested. What can be said with some certainty is that transport is a necessary but not sufficient condition for economic development[14]. New or improved transport infrastructure can bring significant economic benefits when other factors are in place and where performance is constrained by poor accessibility or high transport costs.

Measurable economic effects of transport improvements at a national or regional level tend to be associated only with improvements which introduce a 'step change' in travel times or costs and accessibility. Arguably, both Severn Crossings represented a step change in transport provision for South Wales. The construction of the first bridge reduced journey times by up to 2 hours, enabling 50 miles to be taken off a round trip between South Wales and southern England. A study undertaken following the opening of the first bridge concluded that the

[13]Welsh Affairs Committee - Third Report: the Severn Toll Crossings
[14] Standing Advisory Committee for Trunk Road Assessment (2000)

crossing had encouraged a significant increase in trade across the bridge and had made both sides of the bridge more attractive locations for manufacturing[15]. Importantly, it found no evidence that economic benefits on one side of the bridge had come about to the detriment of the other. In a later study, Cambridge Economic Consultants considered the long term effects of the first crossing[16]. The study suggests that the bridge transformed South Wales from a high transport cost location to an average transport cost location, allowing South Wales businesses to reduce prices by 1.5% without reducing profitability.

The Second Severn Crossing resulted in a more modest time saving but it might be considered that it enabled a step change in reliability and capacity of the major transport corridor in South Wales.

1.2.1 Policy Debates and Trade-offs

The tolls on the Severn Crossings, as is typically the case in the UK and elsewhere, has come about because of a need to finance the construction and maintenance of the bridges, rather than as an attempt to reduce traffic congestion. However, tolls impose an additional cost on users of the crossings which acts to reduce the demand for travelling across the Severn Estuary. The influence of the tolls on the decisions of individual consumers, commuters and businesses may have wider implications for the economy.

For business users, tolls add to the costs of production which they may choose to pass on to customers, with the possible implication of reduced competitiveness, or they may have to absorb the cost, resulting in lower profits. The costs of tolls may influence business decisions over whether to compete in certain markets or whether to invest in particular locations.

For individuals, tolls can act as a disincentive to travel, affecting decisions over where to shop or spend their leisure time. They can also constrain individuals when considering where to look for work. Subsequently, they can act to increase labour costs for businesses. By discouraging economic interaction between businesses and labour, a toll can act as a barrier to the realisation of *agglomeration* effects. Agglomeration effects describe the productivity benefits which come about as a result of interaction between economic actors in areas of dense or concentrated economic activity.

However, removing or altering tolls on transport infrastructure introduces a complex set of trade-offs. The effect of reducing or removing tolls is not always positive for all road users. . Tolls have the effect of suppressing demand and may, therefore, reduce the impact of congestion on other, time-sensitive, users.

Tolls and user charges are increasingly seen as a means of increasing efficiency or producing socially desirable outcomes with respect to the level of traffic congestion or vehicle emissions. Removing a toll will reduce the effective price of using the infrastructure which, in most circumstances, will lead to an increase in demand. More traffic can result in congestion and slower and/or less reliable

[15] 'The Economic Consequences of the Severn Bridge and its Associated Motorways' (Cleary & Thomas, 1973)
[16] Cambridge Economic Consultants 1987, cited in David Simmonds Consultancy, Case Study: The Severn Bridge

journeys. The overall effect may be to benefit cost-sensitive users at the expense of time sensitive users.

A further trade off relates to the impact of tolls on local or national government finances. Where the revenue from toll charges exceed the costs of maintenance and the debt burden from construction, the income collected from transport users can be reinvested into other areas which support policy priorities, such as enhancements to other parts of the road network or improvements in public transport.

1.3 Study Objectives

In December of 2010, the report of the Welsh Affairs Committee enquiry into the Severn Crossings Toll was published. One of the main findings of the Committee was the lack of robust evidence on the impact of the tolls on the economy. This study is the first comprehensive assessment of the impact of the Severn tolls. The complex relationship between the Severn Crossings and the Welsh economy is such that the study covers a broad range of transport and economic issues. The terms of reference for the study cover the following:

- Traffic and transport behaviour – the degree to which travel demand and travel patterns are affected by the tolls, distinguishing between the effects on different types of user;
- The wider transport network – the impacts of tolling on the level of congestion on the Severn Crossings and the wider road network;
- The environment – the effect of tolling on carbon emissions from transport;
- The direct and indirect costs for consumers and businesses – how the direct cost of the tolls is translated into indirect effects, for instance the degree to which the costs of the toll are passed from businesses to customers and the influence of the toll on markets;
- The effect on labour markets - the extent to which the tolls influence the employment decisions of individuals and the effective labour market search area for businesses;
- Influences on business location and investment decisions – the extent to which the tolls influence the location of economic activity and the degree to which toll costs are factored in to decisions about where to invest, and;
- The overall effect on economic performance – the overall effect of tolling on the performance of the economy of Wales.

With respect to each of the above, the intention is to present evidence for nature and possible magnitude of the effect of the tolls. It is not the purpose of this report to provide recommendations for the future of the tolls following the end of the concession agreement. Furthermore, the report does not consider the trade-offs or benefits attached to re-investment of toll revenue which would be made possible at such time.

1.3.1 Scenario analysis

The study considers the potential impact of a range of alternative tolling regimes were they to be introduced at the end of the concession agreement (assumed to be

2018). In practice, there are potentially a huge range of options available to the Government with respect to the future of the tolls on the Severn Crossings. For the purposes of this study, the following three very simple scenarios have been analysed:

Scenario 1 – Reduce tolls on both bridges by 50%;

Scenario 2 – Remove tolls from the Severn Crossings, and;

Scenario 3 – Increase tolls on both bridges by 50%.

Subsequent analysis might consider more complex approaches such as variable tolls which change according to the time of day or the day of the week, alternative means of treatment of different vehicle types or users, or enhanced technologies for toll collection which alleviate delays.

There will inevitably be winners and losers from any future change in tolling. Tolls and road user charges have implications for equity and fairness which, in the end, require political as well as economic analysis. The purpose of these scenarios is to illustrate the nature of the impacts of tolling and to provide some evidence to inform the debate over the future of the tolls. They are not fully developed policy options, but a starting point from which future analysis of policy can begin.

2 Study Approach

2.1 Introduction

One of the difficulties of assessing the impact of the Severn Crossing tolls is the fact that tolls have been in place on the crossings since their opening. Furthermore, toll prices have remained unchanged, in real terms, in recent years. Therefore, it has not been possible to use historic patterns as a basis for predicting the consequences of any future change. Instead, the conclusions of the study are based on what we can infer from existing patterns of behaviour, from secondary evidence, and through modelling the effects based on logical assumptions. This report also builds upon research undertaken by the University of the West of England into relationship between accessibility and peripherality and economic performance.

The following research has been undertaken to inform this report:

- A review of literature on the impact of tolling on transport and the economy elsewhere;
- A high level analysis of traffic flows and the application of a traffic model to simulate the effects of alternative scenarios noted in Section 1;
- A survey of businesses in South Wales and the South West to understand the significance of the tolls, and the perceived effects on business performance and behaviour;
- A number of in-depth interviews with a selection of businesses and representative groups;
- A short survey of consumers in the South West to inform an understanding of attitudes of potential visitors to Wales, and;
- An economic modelling exercise to simulate the effects of tolling on overall economic performance, focussing on the effects on productivity.

2.2 Literature review

This report draws on a review of literature which explores the transport and economic impacts of tolls on road infrastructure in the UK and abroad. The review covered reports produced for public and private sector organisations as well as academic literature from peer-reviewed journals and from conferences. This is summarised in Section 4.

2.3 Traffic and transport modelling

The primary method for estimating the effects of the tolls on transport is the application of a traffic model. Key aspects of the approach are as follows:

- The Application of the ‘M4 Traffic Model’ which covers, in detail the M4 and the surrounding trunk road network in South East Wales, including the Severn Crossings and parts of South West England;
- Refinement of the model to reflect the level of traffic on the Severn Crossings based on recent count data;

- Calculation of toll costs set against total costs of travel for a range of different types of vehicles and users, and;
- An elasticity based approach to predict the response of road users to changes in the toll based on empirical evidence.

More detailed information on the approach to traffic modelling is included in Section 5 and in Appendix A. An analysis of past data on traffic flows and patterns is provided in Section 3.

2.4 Impacts of toll on businesses and consumers

In order to assess the impact of the tolls on businesses and consumers the following research has been conducted:

- A large scale (450 response) telephone survey of businesses located to the east and west of the Severn Crossings (in South Wales and the South West of England). The purpose of the survey is to determine the perceived significance of the tolls for businesses and the implications of the tolls for business performance and behaviour;
- Targeted discussions with a small number of potentially affected businesses and stakeholder organisations in order to gather more detailed insight and evidence around the effect on tolling on businesses, their competitiveness and their investment choices, and;
- An exploratory survey of the perceptions and awareness of potential visitors to Wales of the Severn tolls.

Impacts on businesses and the labour market are considered in Sections 6 and 7 and a summary of the results of each survey is provided in Appendix C and D.

2.5 Econometric modelling

The modelling of the overall economic impact of various toll regimes builds on a 2008 study of the relationship between peripherality, accessibility and productivity undertaken by the University of the West of England. The model in that study has been re-estimated using the latest available firm level and generalised travel cost data in order to estimate the impact of the toll on economic performance measured by Gross Value Added (GVA)

Further information is provided in Section 8 and Appendix B.

3 Traffic and Travel Patterns

3.1 Introduction

This section provides an analysis of available data on traffic flows and travel patterns over the Severn Crossings.

3.2 Traffic Volumes and Travel Patterns

Traffic Volumes and Trends

Table 3.1 below shows the traffic flows (derived from automatic vehicle counts) across the M48 Severn Bridge and M4 Second Severn Crossing for the period 2003-2008 expressed as 'Annual Average Daily Traffic (AADT)[17]'. Since 2003 there has been steady growth in traffic across the M4 Second Severn Crossing, with growth ranging from 1.0% – 3.6% per annum, with an average annual growth over the period of 1.78%. The AADT on the Second Severn Crossing in 2008 was 61,455.

On the M48 Severn Bridge the rate of growth is lower at an average of 0.56% between 2003 and 2008. The absolute level of daily traffic on the M48 is much lower than the M4, with 17,723 crossings in 2008. This reflects the current role of M48 crossing, serving a more localised market with a higher proportion of trips originating in, or destined for Monmouthshire. In contrast, the M4 Second Severn Crossing is more strategic in nature, as the main road link between the South and West of England and Wales and South Wales.

The level of growth observed suggests that the 'strategic' traffic growth (longer distance traffic) been increasing at a greater level than locally generated traffic.

Table 3.1 - Severn Crossing Historic Traffic Flows (eastbound and westbound traffic combined)

	M48 Severn Crossing		M4 Second Severn Crossing	
Year	AADT	Annual % change	AADT	Annual % change
2003	17,239	-	56,277	-
2004	17,155	-0.5%	56,835	1.0%
2005	17,673	3.0%	58,893	3.6%
2006	17,819	0.8%	60,020	1.9%
2007	17,828	0.1%	60,723	1.2%
2008	17,723	-0.6%	61,455	1.2%
Annual Average Growth	-	0.6%	-	1.8%

Source: Traffic Wales (2009)

Growth in traffic across the Second Severn Crossing since 2003 (1.78% per annum) has been above the level of growth observed on other selected parts of the strategic road network in England and Wales, as shown in Table 3.2 below. This

[17] AADT is a measure of annual vehicle flows expressed as an average number of vehicles per day.

shows that in the period 2003-2009 the annual average level of growth across on the strategic road network in England and Wales is only 0.63%, whilst on other parts of the M4 corridor it is 1.24%. As a means of comparison, the M1 and the M6 have observed growth of 0.20% and 1.32% respectively.

Table 3.2 - Strategic Road Network Traffic Growth

Road	Year	AADT	Observed Period	Annual Growth Rate
M48 Severn Crossing	2008	17,723	2003 – 2008	0.56%
M4 Second Severn Crossing	2008	61,455	2003 – 2008	1.78%
M4 South Wales	2009	72,704	2003 – 2009	1.24%
M1 South of the M6 Junction	2009	102,700	2003 – 2009	0.20%
M6 South of M62	2009	108,814	2003 – 2009	1.32%
UK Average	2009	76,500	2003 – 2009	0.63%

Source: Traffic Wales (2009), Highways Agency

Recent Trends

The above traffic counts fail to provide a consistent measure of more recent trends in traffic flows over the Severn Crossings. However, toll booth data taken from the concessionaire's annual accounts does provide a measure of the number of vehicles crossing the bridges in a westbound direction. As might be expected, there has been a slight reduction in the number of vehicles using the bridge since the economic downturn of 2008.

Table 3.3 - Westbound vehicles

	2008	2009	2010
Westbound toll paying vehicles	12,921,459	12,524,125	12,428,765

Source: Severn River Crossings plc, annual report

Directional Imbalance

Table 3.4 shows the AADT on both Severn Crossings in 2005 by direction of travel. This shows that across both bridges there is a small directional imbalance, with 4.7% more traffic in the eastbound direction compared with the westbound direction. This is due to the fact that the toll is charged only in the westbound direction and therefore a small proportion of traffic crossing use an alternative route to make the westbound trip (via Gloucester). This may also be the result of drivers on round trips (for example businesses delivering at multiple locations) organising their stops such that they avoid paying the toll.

Table 3.4 - AADT by direction on the Severn Crossing (5-day averages, September 2005)

	East Bound	West Bound	Directional Imbalance (Eastbound / Westbound)
M48	7,391	7,783	-5.0%
M4	32,881	30,696	+7.1%
Total	40,272	38,479	+4.7%

Source: Arup M4 Traffic Model

Daily Profile of Traffic

Figure 3.1 and Figure 3.2 below show the split in the daily traffic by direction for the M48 Severn Crossing and the M4 Second Severn Crossing. The traffic profiles in Figure 3.1 and 3.2 show that there are distinct traffic peaks on both crossings in the AM Peak between 07:00 and 09:00 and in the PM Peak between 16:00 and 18:00. This would indicate that both crossings carry a significant number of commuter trips between South Wales and South West England.

The data also shows that the 'spike' in traffic in the AM Peak is more pronounced in the eastbound direction than the westbound direction, with the opposite in the PM Peak with traffic returning westbound. This indicates that there is more traffic travelling from South Wales to England in the morning period and returning in the PM Peak than in the opposite direction. Given the profile of commuting between Wales and England (described further in Section 3.8 below), an imbalance in the flows of workers across the Severn is likely to be a key explanatory factor. An imbalance in business travel and goods movements may also contribute to this observation although there is less evidence to corroborate this. The imbalance is not as pronounced on the M48 Crossing, with approximately similar flows in each direction in both peak periods.

Figure 3.1 - M4 Second Severn Crossing Hourly Profile (Eastbound and Westbound flows)

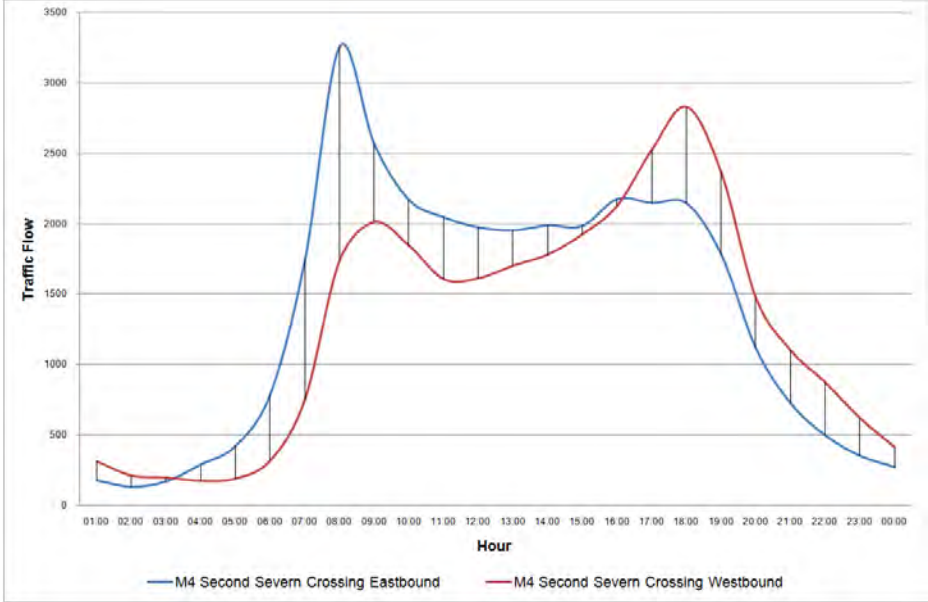
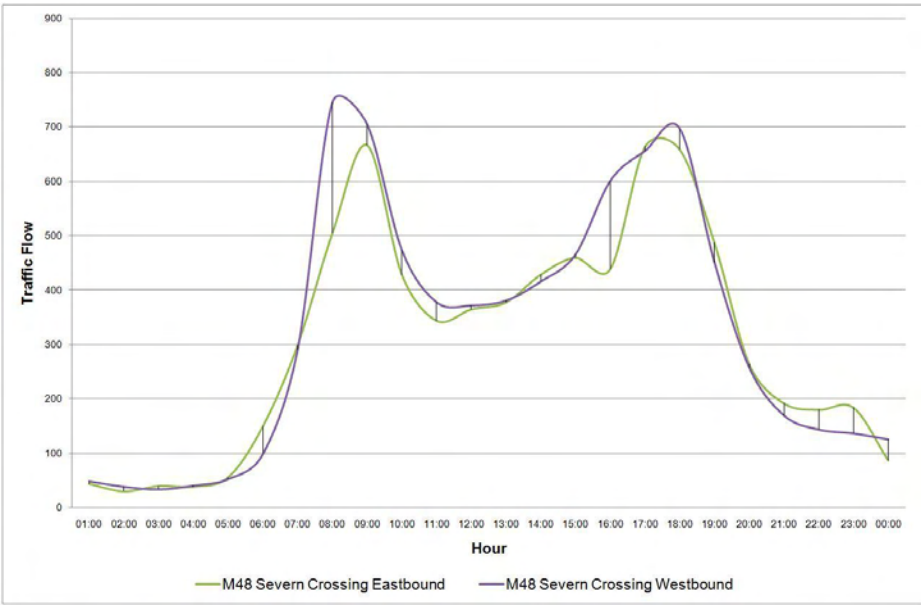


Figure 3.2 - M48 Second Severn Crossing Hourly Profile (Eastbound and Westbound flows)



3.3 Travel Patterns

Tables 3.5 and 3.6 show the dominant origins and destinations of trips crossing the M48 and the M4 crossings in both the eastbound and westbound direction. This is based on data from a survey of drivers undertaken in 2005 which is the last available survey of users. The data clearly illustrates the different roles played by each of the two crossings. Whilst the origins and destinations of traffic using the M48 Crossing are focused on Monmouthshire, Bristol and the South West of England (in both directions), the M4 Crossing serves a much wider market, with

origins and destinations across all areas of South Wales and across southern England.

Table 3.5 - Distribution of Trips by Origin and Destination (M4 Second Severn Crossing)

Area of origin/destination	% of Trips by Destination	% of Trips by Origin
Newport	10.9%	10.9%
Cardiff & The Vale	14.1%	13.7%
Monmouthshire	4.7%	6.0%
East Valleys	5.9%	6.9%
West Valleys	6.0%	6.4%
Swansea	2.6%	2.9%
South West Wales	3.0%	3.4%
North & Mid Wales	1.1%	1.1%
Greater Bristol	23.8%	24.6%
Rest of South West England	14.7%	13.2%
East and West Midland	0.9%	0.2%
South East and East England	9.0%	7.7%
London	3.2%	2.9%
Northern England	0.1%	0.0%

Table 3.6 - Distribution of Trips by Origin and Destination (M48 Second Severn Crossing)

Area of origin/destination	% of Trips by Destination	% of Trips by Origin
Newport	3.6%	2.3%
Cardiff & The Vale	0.7%	2.1%
Monmouthshire	28.7%	29.3%
East Valleys	0.6%	0.4%
West Valleys	1.2%	1.3%
Swansea	0.7%	0.7%
South West Wales	0.0%	0.0%
North & Mid Wales	0.5%	0.1%
Greater Bristol	40.7%	38.8%
Rest of South West England	19.3%	15.0%
East and West Midland	0.6%	7.1%
South East and East England	2.2%	1.9%
London	1.1%	1.0%
Northern England	0.2%	0.0%

3.4 Journey Times

As noted, there is an imbalance in eastbound and westbound movements across the Severn Crossings which reflects, in part, the use of alternative routes to avoid

the tolls. However, for the majority of movements, avoiding the westbound crossing is clearly impractical. Table 3.7 provides a comparison of the average journey times between South Wales and South West England using the M4 / M48 Crossings and the non-tolled route via Gloucester. This shows that for a trip between Newport and Bristol the non-tolled route is, on average, over an hour longer, at 1hr 41 minutes compared with 36 minutes via the M4 (tolled route). It is likely that an alternative route to the crossings will only be considered a good substitute to the tolled route for a trip originating in Gloucestershire and parts of the Midlands.

Table 3.7 - Example Journey Time between South Wales and South West England

	Via the M4 or M48 Severn Crossing	Via Gloucester (non-tolled route)
Newport to Bristol	36:21	1:41:07
Cardiff to Bristol	53:57	1:59:27
Bristol to Newport	35:19	1:43:37
Bristol to Cardiff	58:13	2:05:41

3.5 Severn Crossing Toll Rates and Revenue

Toll Revenue

Table 3.8 shows the current toll tariffs by vehicle type. These show that the toll for cars and other vehicles in 2011 with up to 9 seats was £5.70, for small buses and vehicle up to 3.5 tonnes the toll was £11.50 and for all other vehicles £17.20.

Table 3.8 – Severn Crossing Tolls in 2011

Category	Toll Tariff
Cat 1; Cars (up to 9 seats)	£5.70
Cat 2; Small buses up to 17 seats and vehicle up to 3.5tonnes	£11.50
Cat3; Vehicle 18 seats and more and vehicles over 3.5 tonnes.	£17.20

Table 3.9 shows the level of toll revenue collected by the concession company – Severn River Crossings (SRC) plc – at the toll plazas. The revenue gained by SRC plc excludes VAT which has been applied to the toll prices since 2003. Therefore, the amount paid in cash by drivers exceeds total revenue. Whilst consumers will pay the full amount of the toll plus VAT, business users are able to claim back the VAT.

Annual revenue in 2009 was over £77m but fell slightly to £76m in 2011. During the period 2005 – 2009 period toll revenue has increased, at an average of 2.54% per annum. Growth reflects higher nominal charges to a greater degree than changes in traffic volume.

Table 3.9 – Historic Toll Revenue (current prices)

	2006	2007	2008	2009	2010
Revenue (million)	£72m	£76.1m	£77.6m	£77.4m	£76.0m
Tolls payments (approximate cash amount including VAT)	£85m	£89m	£91m	£89m	£89m

Source: Severn River Crossing PLC Annual Report

Traffic data suggests that around 26% of toll revenue (£20m excluding VAT) relates to Heavy Goods Vehicles (HGVs) and 15% (£11m excluding VAT) is from Light Goods Vehicles (LGVs). Car drivers pay around £45m a year on tolls (excluding VAT).

Although an accurate breakdown is not available, applying survey data suggests that approximately 35% (£16m excluding VAT) of toll payments by car drivers are made by drivers on work time (business travel). The remainder (£34m if VAT is included) is fairly evenly split between drivers travelling to and from work and 'other' car trips (leisure trips or other purposes)[18].

Taking all goods vehicles toll payments and toll payments of business users, the direct toll costs imposed on businesses can be roughly estimated to be £47m (excluding VAT) in 2009 prices, with remaining £34m (including VAT) being paid by consumers. Therefore the total cost to businesses and consumers, once reclaiming of VAT is taken into account, is in excess of £80m a year.

There is no data available which allows an accurate assessment of how these costs are split between vehicles and businesses based in Wales, or elsewhere. Given that it is likely that there is some 'cost pass through' or sharing of toll costs between the toll payer and the end customer this is highly complex. This is explored further in Section 6.

3.6 Tolls and Total Journey Costs

It is useful to place the cost of the toll in the context of total journey costs, taking into account fuel costs, vehicle maintenance and depreciation costs as well as the opportunity cost of time spent travelling (referred to as 'value of time'). A range of typical journeys are provided in Table 3.10 below. Average costs and 'values of time' for different road users provided by the Department for Transport for this purpose. The toll is halved to reflect the fact that most users use the bridges in both directions as part of a return trip, whilst the toll is only charged in one direction.

The proportion of trip costs accounted for by the toll varies greatly across different types of user. For a car journey (excluding commuters and business travel) the toll represents approximately 19% of trip costs for a journey between Cardiff and Bristol. For a business traveller, considering the value of lost productive time, toll costs fall to approximately 8% of trip costs. For goods vehicles making the equivalent journey, tolls represent between 21% (HGVs) and 23% (LGVs) of total journey costs for goods vehicles. Toll costs as a proportion of total journey costs diminish significantly with distance travelled.

[18] Figures are based on survey data of M4 and M48 users applied to total revenue taken from SRC plc accounts.

Table 3.10 - Journey cost between example O/D pair using the M4 Second Severn Crossing at AM Peak

	Time Cost	Fuel Cost	Operating cost	Toll Cost	Toll Cost/Total Cost
Cars on Employer Business					
Newport to Bristol	£14.06	£1.91	£2.45	£2.04	10%
Cardiff to Bristol	£20.87	£2.84	£3.64	£2.04	7%
Bristol to Newport	£13.66	£1.86	£2.38	£2.04	10%
Bristol to Cardiff	£22.52	£3.06	£3.92	£2.04	6%
Car Others					
Newport to Bristol	£2.87	£2.24	£1.61	£2.40	26%
Cardiff to Bristol	£4.26	£3.33	£2.40	£2.40	19%
Bristol to Newport	£2.79	£2.18	£1.57	£2.40	27%
Bristol to Cardiff	£4.59	£3.59	£2.58	£2.40	18%
Car Commuters					
Newport to Bristol	£3.24	£2.24	£1.61	£2.40	25%
Cardiff to Bristol	£4.81	£3.33	£2.40	£2.40	19%
Bristol to Newport	£3.15	£2.18	£1.57	£2.40	26%
Bristol to Cardiff	£5.19	£3.59	£2.58	£2.40	17%
Light Goods Vehicles (LGVs)					
Newport to Bristol	£5.42	£2.52	£2.79	£4.09	28%
Cardiff to Bristol	£8.04	£3.73	£4.14	£4.09	20%
Bristol to Newport	£5.26	£2.44	£2.71	£4.09	28%
Bristol to Cardiff	£8.67	£4.03	£4.47	£4.09	19%
Heavy Goods Vehicles					
Newport to Bristol	£5.42	£7.14	£5.23	£6.09	26%
Cardiff to Bristol	£8.04	£10.60	£7.77	£6.09	19%
Bristol to Newport	£5.26	£6.94	£5.09	£6.09	26%
Bristol to Cardiff	£8.67	£11.44	£8.38	£6.09	18%

Source: Arup M4 Traffic Model

Toll Booth Delay

An additional 'cost' to Severn Crossing users is the necessity to stop and, on occasion, to queue at the toll booths. There is no up to date data on the frequency and length of delays experienced at toll booths. Anecdotally, users observe that delays at toll booths can be significant with longer delays typically limited to peak periods, during holiday period, or in the run up to a major events taking place in South East Wales.

Tables 3.11 and 3.12 show observed westbound journey times on the M4 and M48 crossings from 2007. The results show that higher delays occur at the M4 toll plazas than at the M48 toll plaza, with the maximum delay of 3 minutes 32 seconds at the M48 toll plaza and nearly 6 minutes at the M4 toll plaza. This is

reflective of the higher usage of the M4 Crossing compared with the M48 Crossing. The results also show that the journey times are longest in the PM peak period on both crossings, which may partly reflect the imbalance in traffic flows through the day, due to commuters and business traffic returning to Wales in the afternoon.

It should be noted that these estimates are averages which do not illustrate the variance in toll delays which are experienced in reality. Such variability, and the implications for journey planning, imposes additional costs on drivers.

Table 3.11 - M48 Severn Crossing between Junction 2 and Junction 21 (Spring 2007)

	Westbound			
	Journey Time (minutes)		Toll Delay (minutes)	
	Average	Max	Average	Max
AM Peak	08:14	10:01	00:25	00:49
Inter Peak	09:08	11:54	01:26	03:32
PM Peak	09:11	10:30	01:11	01:58

Source: Traffic Observations, 2007

Table 3.12 - M4 Second Severn Crossing between Junction 23 and Junction 22 (Spring 2007)

	Westbound			
	Journey Time (minutes)		Toll Delay (minutes)	
	Average	Max	Average	Max
AM Peak	12:55	16:00	02:45	05:55
Inter Peak	11:24	12:55	01:00	02:11
PM Peak	13:12	15:23	02:29	05:00

Source: Traffic Observations, 2007

3.7 Trends in Transport Costs

The price of the toll changes on an annual basis in line with the change in the Retail Price Index (RPI) for the previous 12 months. Therefore the tolls have been fixed in real terms in recent years. Other costs of transport have changed in real terms over time which affects the way drivers and businesses perceive the toll. Figure 3.3 and Figure 3.4 show the trend in toll costs compared with measures of other aspects of transport costs. These results show that in comparison with variable costs of transport (fuel, maintenance and tax), tolls costs have increased more slowly, meaning that the proportional cost of the toll in terms of a total *journey* costs has reduced since 2000. However, the costs of purchasing vehicles has fallen, meaning that toll cost inflation has exceeded overall motoring cost inflation.

Figure 3.5 shows that toll costs have increased at a higher rate than the costs of bus, coach and rail fares, meaning they have become more significant in comparison with other modes of travel. In comparison with GDP/Capita and

household incomes in Wales, tolls costs have risen more slowly. This indicates that toll costs have become less expensive relative to incomes in Wales since 2000.

Figure 3.3 - Toll price and vehicle related costs

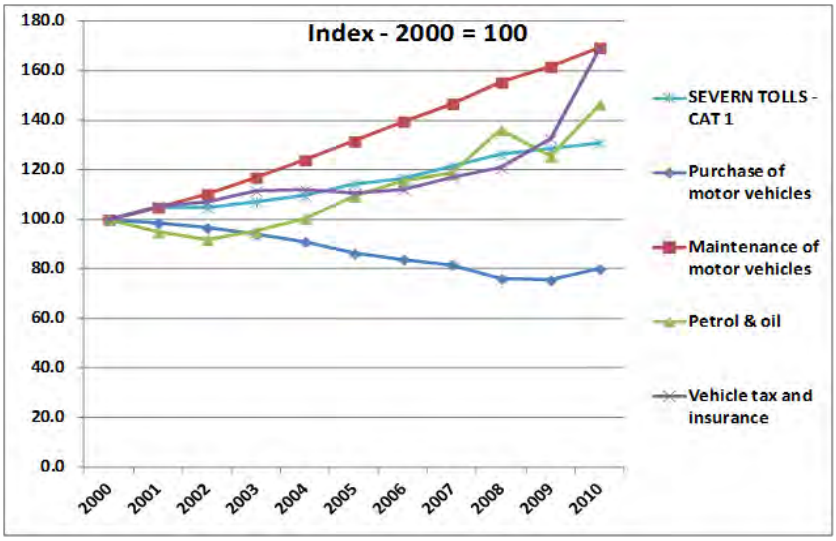


Figure 3.4 - Toll price and overall transport costs

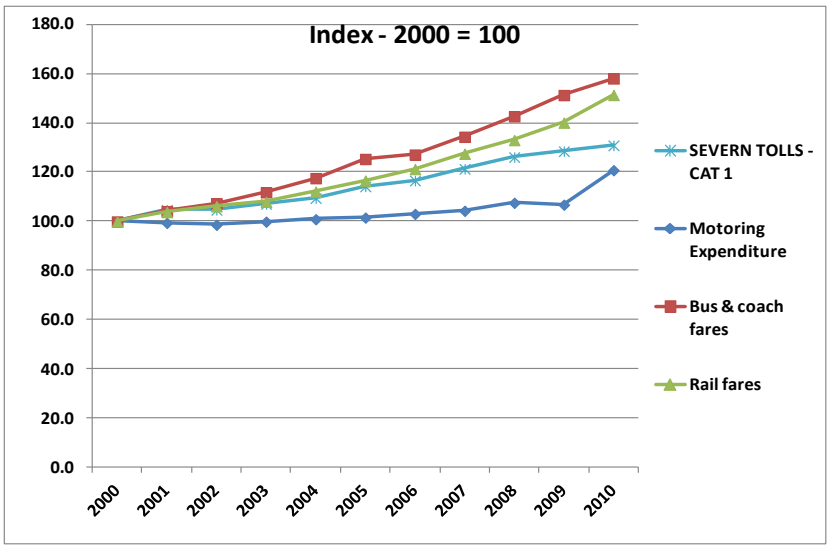
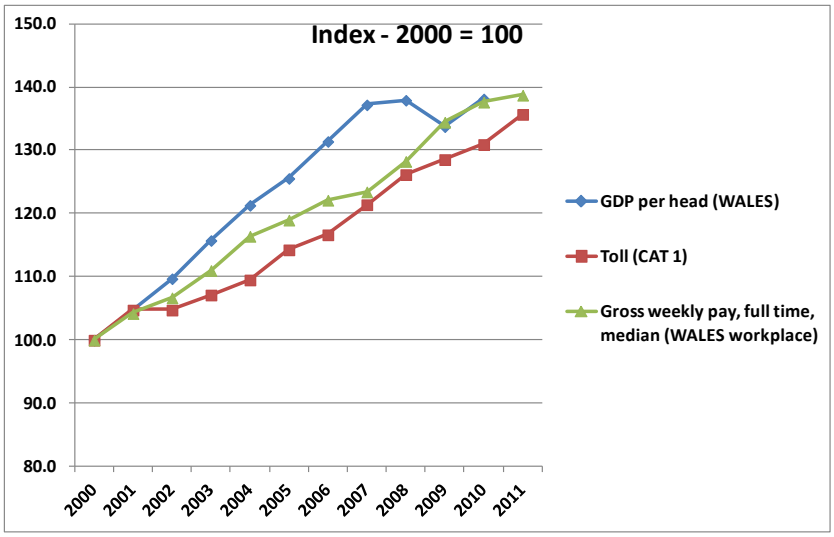


Figure 3.5 - Toll price, wages and GDP (Nominal)



3.8 Commuting Patterns and the Severn Crossings

Work-related mobility is one reason why people use the Severn Crossing although work-related mobility is more than just commuting traffic. In a contemporary economy there appears to be an increasing interest in forms of work-related mobility such as teleworking that might include a worker's home address as a base or that might involve workers operating at multiple and changing sites of work (see Ruiz and Walling, 2005). Work-related mobility might also include a workforce that has a 'base' but that involves mobility during the course of the working period ('at work').

The available evidence on work-related mobility in general and on work-related mobility specifically within the Severnside region focuses principally on mobility related to commuting (broadly the journeys made by workers to get from a place of residence to a place of work). Whereas questions relating to commuting are asked in the Labour Force Survey, the survey sample size restricts our capacity to say a lot about the detailed commuting patterns that might be witnessed in the Severnside region between local authority areas. Thus the evidence on much of the probable detail of commuting patterns depends upon a consideration of the 2001 Census of Population.

3.8.1 Commuting Patterns

The analysis distinguishes between the local authorities within the English and Welsh 'Severnside' areas. These areas have been defined so that they capture the bulk of commuting flows between the South and West of England and South Wales, the area for which the Severn Crossings are a likely travel option.

Census data (Table 3.13) suggests that around 6,600 commuters travelled from Welsh Severnside to English Severnside with a further 8,500 commuters travelling to work in other parts of England (London, the South East and the West Midlands for the most part). These flows are significantly higher than the flows from England to Wales with only 2,000 commuting movements from East to West Severnside. The three principal local authority areas accounting for most of these flows from West to East are Monmouthshire, Cardiff and Newport. Comparing

the commuting flows from the East and West Severnside regions, those in employment who live in Welsh Severnside are slightly more likely to commute further than those who live in the English Severnside. Thus workers in Welsh Severnside are 10% more likely to commute 20km than might be expected looking at commuting patterns in the region as a whole.

Table 3.13 - Total commuting flows in and around Severnside region, 2001

Area of residence	area of workplace				
	English Severnside	Welsh Severnside	South West (not Severnside)	Wales (not Severnside)	Rest of England
English Severnside	482,120	2,030	22,971	252	10,861
Welsh Severnside	6,623	428,952	-	21,049	8,427
South West (not Severnside)	29,087	-	1,429,418	-	58,336
Wales (not Severnside)	1,277	31,268	-	636,212	42,851
Rest of England	9,085	4,356	44,689	24,447	19,977,228

Source: 2001 census - UK travel flows (local authority) - ONS Crown Copyright Reserved [from Nomis on 18 May 2011]

- Insignificant commuting flows for these movements

3.8.2 Profile of Severnside Commuters

Table 3.14 sets out the profile of commuters between East and West Severnside in relation to their socio-economic group (National Statistics classification of Socio-Economic Class). Greater proportions of the commuting workers (in both directions) are made up of higher occupational class (and thus higher earning) than is the case for the population commuting within either of the sub-regions. This would be expected given that workers in more professional occupations are likely to commute further because they earn more. Thus the commuting flows across the Severn are more likely to include workers at large employers, higher level managers and professional workers (accounting for 65% of commuters but fewer than 40% of those who live and work in either East or West Severnside). It is notable that a greater proportion of higher managerial workers commute east to west than make the commute from Wales to England (though in numerical terms there is still a net commuting in-flow into England). Low and semi-skilled workers are less likely to commute than to work within either part of the sub-region although in the case of workers living in Welsh Severnside, a greater proportion of workers from lower supervisory and technical occupations commute to English Severnside than commute in the opposite direction.

Evidence based on comparing the Labour Force Survey between 2001 and 2008 suggests that commuting patterns in the Severnside region have not significantly altered over the decade.

Table 3.14 - Commuting flows profiled by Socio-Economic classification, 2001

	% commuting flows made up by:							
	Large employers and higher managerial occupations	Higher professional occupations	Lower managerial and professional occupations	Intermediate occupations	Small employers and own account workers	Lower supervisory and technical occupations	Semi-routine occupations	Routine occupations
Within English Severnside	4.2	8.2	26.2	13.6	9.7	9.1	14.7	10.1
English to Welsh Severnside	15.0	19.1	39.5	5.9	2.7	6.6	3.2	4.9
Welsh to English Severnside	10.1	18.3	36.8	9.4	2.4	9.7	4.7	5.9
Within Welsh Severnside	3.5	6.7	25.3	13.5	8.3	10.6	15.9	12.5

Source: 2001 Census - UK travel flows (Local Authority) - ONS Crown Copyright Reserved [from Nomis on 18 May 2011]

4 Evidence from Toll Roads Elsewhere

4.1 Introduction

A review of evidence from toll roads elsewhere has been undertaken in order to identify experience which is applicable to the Severn tolls. The review focuses on ex-post assessment of the introduction or removal of tolls on traffic volumes, transport and the economy. However, due to the lack of relevant studies, evidence from ex-ante appraisal has also been incorporated. The review focuses separately on impacts on transport and on the economy.

4.2 Effects on Traffic and Transport – The Toll Price Elasticity of Demand

The *'elasticity of demand'* describes the responsiveness of demand (in this case demand for the use of a tolled road) to a change in price (in this case the level of a toll imposed on users) [19]. Empirical evidence on the demand elasticity with respect to tolls is limited because of the relative scarcity of tolled roads and crossings worldwide, as well as the lack of ex-post assessment of the effects of tolls.

In general, toll price elasticities drawn from existing studies tend to be based on the introduction of a toll, rather than removal or reduction. Whilst the issues are the same (albeit reversed) for the introduction or removal of a toll, it could be the case that there is some asymmetry in response, at least in the short term. Such asymmetry could be linked to the importance of the psychological aspects of toll response which are discussed further in Section 5.

The elasticity of demand with respect to a toll is highly dependent on a range of local and contextual factors. Therefore, estimates of toll elasticities vary widely across the literature, limiting the degree to which the results can be directly applied to the Severn Crossings. However, the literature is instructive in that it provides a range within which toll elasticities are typically estimated to lie. Furthermore the literature also identifies a number of relevant factors or characteristics which influence the magnitude of the elasticity.

4.2.1 The range of elasticity estimates

A summary of toll elasticities found in the literature is shown in Table 4.1. For bridges and crossings, elasticities range between -0.09 to -0.5. A larger range is found for tolled roads of between -0.03 and -0.83. All of the toll elasticities found in the literature are less than 1 (i.e. the change in traffic is less than the change in toll price) suggesting that transport demand is relatively inelastic to tolls.

A number of studies have compared the traffic response over a number of different tolled routes. For example, a comparative study of toll roads in Spain (Matas and Raymond, 2003) finds short term elasticities within the range of -0.21 to -0.83 depending on a range of characteristics, the most significant factor being

[19] The elasticity gives the change in demand that results from a change in price. For example, an elasticity of
-0.10 means that should a toll double in price (a 100% increase) that the number of users of the tolled road would fall by 10%.

the quality of alternative routes. The majority of studies place toll elasticities towards the lower end of this spectrum. A study of six bridges and two tunnels in the New York City area (Hirschman et al, 1995) found a range of between -0.09 and -0.50 with an average of -0.25. A study of toll roads in Norway (Odeck & Brathan, 2008) finds a similarly wide range of between -0.45 and -0.8.

Table 4.1- Summary of toll elasticity evidence

Tolled facility	Elasticity	Source
Bridges and Crossings		
15 toll bridges in the US	-0.15 to -0.31	Weustefield and Regan (1981)
Bridges in Southampton (UK)	-0.14 to -0.29	White (1984)
Golden Gate and San Francisco Bay Bridges	-0.05 to -0.15	Harvey (1994)
Six bridges and two tunnels in New York City	-0.09 to -0.50	Hirschman et al (1995)
Golden Gate Bridge	-0.15	Gifford and Talkington (1996)
Toll Roads		
19 rural roads, trunk roads and urban motorways in Norway	-0.45 to -0.8	Odeck and Brathen (2008)
16 tolled facilities in the US	-0.03 to -0.31	Weustefield and Regan (1981)
Three intercity motorways in Spain	-0.15 to -0.48	Ribas et al (1988)
Alesund (Norway) road schemes	-0.22	Jones and Hervik (1992)
Journeys over 100kms on French motorways	-0.22 to -0.35	INRETS (1997)
The New Jersey Turnpike (US)	-0.20	UTM (2000)
Panel data on 72 road sections in Spain	-0.21 to -0.83	Matas and Raymond (2002)
Car travel in Singapore	-0.19 to -0.58	Luk (1999)

Source: Arup analysis

4.2.1.1 UK evidence

Due to the relative rarity of toll roads in the UK, few elasticity estimates were found by the literature review. An exception is the Humber Bridge which has been the subject of various analyses around the impact of tolls. A study carried out in 2004 (Steer Davies Gleave) did not seek to estimate the elasticity of demand directly, but found little evidence of people making detours to avoid paying the toll and no obvious relationship between year-on-year toll increases (above inflation) and the level of traffic on the bridge. This implies a relatively inelastic response to toll price changes.

The M6 Toll Road has perhaps received the greatest amount of scrutiny of tolled routes in the UK and is the only toll road in the UK built with the specific aim of overcoming a congestion issue by asking drivers to pay to avoid delays. The M6 toll road is a 43km stretch of motorway around Birmingham which opened to traffic in late 2003 with a toll of £2 for cars. Forecasts for the use of the road were based to a large extent on stated preference survey approaches in

combination with traffic models, which put simply asked respondents to make a series of hypothetical choices between toll payments and journey times.

The actual traffic flows observed on the M6 toll road has been around 35,000 to 40,000 vehicles per day while forecasts had predicted around 70,000 vehicles per day. Traffic on the untolled M6 did reduce significantly, although the volume of Heavy Goods Vehicle on the bypassed route changed little. In 2005, only 7% of traffic on the M6 toll road was HGVs compared to between 27% and 35% on parts of the untolled M6.

Another evaluation report (published in 2009) was undertaken 5 years after opening. The study concluded that the toll road continued to help alleviate congestion and improve journey times on the untolled M6. However, the level of traffic on the M6 toll road actually fell after 2007 with recreational traffic being the group returning to the untolled M6 in greatest numbers. This reduction is partly explained by the effects of the recession. Overall, traffic on the untolled M6 had returned to levels experienced before the toll road opened.

Another instructive aspect of the M6 experience is the unwillingness of the majority of heavy goods vehicles to use the tolled route. This might suggest that freight operators or other businesses moving goods place significant weight on tolls in their route decisions.

Drawing direct inferences for the Severn Crossings in terms of traffic responses is extremely difficult given the contrasting choices facing M6 and M4 users. In the case of the M6 there is a clear and viable (albeit slower and less reliable) alternative for drivers. For the Severn Crossing, for the majority of journeys, alternative routes and modes might be considered infeasible. Therefore the network or assignment effects will be the dominant response to tolls on the M6, whilst in the case of the Severn Crossings such effects will be much less significant and decisions about whether to travel (or to travel by road) in the face of toll costs could be more significant.

4.2.1.2 Detailed evidence on elasticity variables

This section provides an analysis of the factors which affect whether demand for a toll road is elastic or inelastic.

The Availability of Alternative Routes

Mattas & Raymond's 2002 study of toll roads in Spain is particularly interesting as it sets out to explain the variance in toll elasticities by applying dummy variables reflecting the attributes of the route. One of the attributes which proved significant was the quality of the tolled route relative to an un-tolled alternative route as measured by average speed. The study confirms that demand is more sensitive to price when the alternative free road is of better quality. Secondly, the study finds that demand tends to be slightly more elastic for longer sections of road, although the study concludes that this can be explained by the fact that demand is more sensitive to price when the total amount to be paid is larger.

Preferences of Different Users

A study of the M6 Toll Road undertaken post-implementation (Fowkes et al., 2007) found evidence that those travelling further had a much stronger preference for the toll road than those on shorter journeys. The study used a stated

preference approach and gathered responses on both the tolled and untolled routes. The analysis failed to find significant differences in the responses of different trip purposes. However, business travellers and commuters were more reluctant than leisure travellers to change their time of departure in the case of variable tolls. As expected higher income respondents exhibited less sensitivity to tolls in their responses.

A New York study (Hirschman et al 1995) considered three vehicle types – passenger cars, light trucks and heavy trucks. As can be seen in Table 4.2, generally trucks were found to have higher toll elasticities than cars. This is perhaps indicative of a high level of time sensitive commuting and business travel by car in New York. Elasticities for heavy trucks appear to be more variable than those for cars.

The fact that a number of studies have found heavy vehicles to be responsive to tolls is an interesting result given that the conventional approach to traffic modelling, is to assume that overall freight traffic demand is fixed and doesn't vary with transport costs such as fuel price increases. It is important therefore to consider the proportion of the demand response which is accounted for by network effects (choosing an alternative route) and the proportion which relates to trip frequency or distribution. In the case of the M6, the response to the toll is very much linked to route choice and this is very possibly also the case in New York.

Table 4.2- Toll Elasticities for a range of tolled tunnels and bridges in New York

	Brooklyn Battery Tunnel	Queens Midtown Tunnel	Triboro Manhattan Plaza	Triboro Bronx Plaza	White-stone Bridge	Throg's Neck Bridge	Henry Hudson Bridge	Verrazano Narrows Bridge
Passenger Cars	-0.26	-0.07	-0.03	-0.13	-0.09	0.19	-0.50	-0.10
Light Trucks	-0.54	-0.45	-0.14	-0.07	-0.13	-0.12	-	-0.17
Heavy Trucks	-0.60	-0.60	0.00	-0.14	-0.09	-0.01	-	-0.20

Source –Hirschman et al. 1995

A 2005 study (Holguin-Veras, Ozbay and de Cerreno 2005) further illustrates the variance in response of users relating to their purpose of travel through an analysis of traffic during peak and off-peak periods. The study found that the traffic response to tolls to be more exaggerated during off-peak periods with short term elasticities increasing from a range of -0.31 to -1.97 for weekdays to -0.55 to -1.68 for weekends. This is likely to be linked to the higher levels of non-work related travel during the weekend.

Short Run vs Long Run Elasticities

A study of 19 toll roads in Norway (Odeck and Bratham, 2008) compared short and long run traffic responses. The data showed average elasticities of -0.54 in the short run and -0.82 in the long run. Importantly Odeck and Bratham find that most of the 'demand adjustment' from short run to long run took place within a year of introduction.

The study also considered how attitudes to tolling change over time. The study finds that people tend to be much more positive about tolls once they are in place

compared to their feelings or expectations prior to implementation. It is not clear, however, the extent to which this change in attitude is due to users becoming accustomed to tolls following initial resistance or if this reflects people's experience of reduced congestion as a result of tolling. The study does note that following removal of tolls, many users realise that tolls were 'a good thing after all', although again such attitudes are likely to be highly related to the degree of congestion.

In contrast, a study of another toll road in Norway (Jones and Hervick, 1992) found that the introduction of a toll resulting in an initial reduction in traffic was followed by a recovery in traffic levels after just three months. In this example, demand was less elastic in the long run than the short run. This might suggest that the initial psychological effect of the introduction of a toll had a significant effect in the short term, replaced by more 'rational' responses after a short period of time.

4.3 Economic Effects of Tolled Infrastructure

As with transport effects, a review of the literature on the economic effects of toll roads highlights the difficulty of applying experience from elsewhere given the strong influence of local and contextual factors. The desire to isolate examples relating to tolled motorways on an 'inter-urban' route such as the Severn Crossings, reduces the scope for useful case study analysis. Moreover, there is a particular lack of studies which analyse the *ex-post* transport and economic effects of the change in tolling regime.

There are a number of ex-ante studies which have considered what might happen should a toll be removed. The Humber Bridge has undergone two recent assessments which consider the ex-ante effects of toll removal. The Humber Bridge Tolls Impact Study (Steer Davies Gleave, 2004) forecast limited local economic benefit where impacts on local businesses may do no more than result in marginally higher profits without having any effect on employment or output. This study added that toll removal may constitute an inefficient means of creating jobs in the area. In contrast, the Humber Bridge Impact Study (Colin Buchanan, 2009) projected a total city-regional benefit from abolishing the tolls to be around £1.1bn over the period 2009-2032 and points towards positive effects arising from increasing the size of the labour catchment area and increasing retail choice for residents in the Hull City Region.

The 'Toll Impact Study' commissioned by the Scottish Government into the effects of removing tolls on the Forth and Tay road bridges anticipated a marginal but positive local economic impact for the residents of Fife despite an expected increase in congestion should the toll be removed from the Forth Bridge. The same report found that in the case of the Tay Bridge that the toll removal would be expected to have a net positive impact on the private sector though the loss of public sector toll income was expected to be more than twice the magnitude of the positive impact. This report predicted that traffic on the Forth road bridge would increase by 10% if the tolls are removed and the Tay bridge to increase 20% northbound and 40% southbound (tolled direction).

There is also limited ex-post evidence of the wider economic impacts of the removal of tolls from crossings. A 2007 report by Derek Halden Consultancy Ltd found that the removal of the toll on the Skye Bridge has had a mixed effect on

local markets. In general, DHC Consultants felt that companies who were already successful have become more successful, and those who were facing decline have seen the rate of decline grow. The report also concluded that removal of the tolls had helped reintegrate the local economies either side of the bridge.

5 Impacts on Traffic and Transport

5.1 Introduction

This section provides high level estimates of the impact of each of the toll scenarios on traffic flows over the crossings. Additional analysis is provided which considers the subsequent effects on traffic flows on congestion elsewhere on the M4 corridor as well as estimates of the effect of tolling on carbon emissions. The approach to the traffic forecasts and key assumptions made are set out below and described in detailed in Annex A.

5.2 Behavioural Responses to Toll Penalties

The overall transport response to a toll is made up of the decisions of each individual user faced with a hugely complex set of choices and motivations. Predicting the effect on traffic flows and transport behaviour inevitably requires a simplification of these effects. In respect of the introduction of a toll or a change in a tolling regime, some effects are likely to be immediate. In other cases, behaviour will adapt over time. The following effects have been identified:

- Network / assignment (short term) – traffic choosing alternative routes to avoid paying tolls but continuing to take the same journeys;
- Mode choice (short/medium term) – people using public transport rather than private cars to avoid paying tolls;
- Vehicle occupancy (short/medium term) – increased car sharing in order to share the cost of a toll;
- Trip frequency (short/medium term) – potential users deciding to travel less often or not at all in response to a toll;
- Trip distribution (short/medium/long term) – people changing their travel patterns (destinations of travel) in response to a toll (for example, choosing an alternative shopping centre, effects on market size for non-retail businesses, or commuters adjusting their employment search area in response to changed travel costs); and
- Land use (long term) – people (i.e. commuters) choosing where to live according to the costs of transport to work and business choosing where to invest based on the effect of transport costs on competitiveness.

5.3 Determinants of Toll Responses

Toll responses are unique to the specific toll road, its context and users. As noted, responses also change over time. The main factors influencing the toll elasticities are listed below:

Route and contextual factors:

- Quality of alternative routes – the relative speed, quality and reliability of tolled and alternative routes is a major factor in determining elasticity. Fewer or less feasible alternatives would, other things being equal, be associated with more inelastic demand;

- Levels of congestion – similarly, the level of congestion on the tolled versus the untolled alternative will be important. Congestion on untolled routes provides an incentive to pay tolls. Congestion or delay caused by toll payment can act to offset this; and
- Existence and quality of alternative modes – the cost, speed and reliability of bus and rail alternatives will determine how many potential users are incentivised to opt for alternative modes.

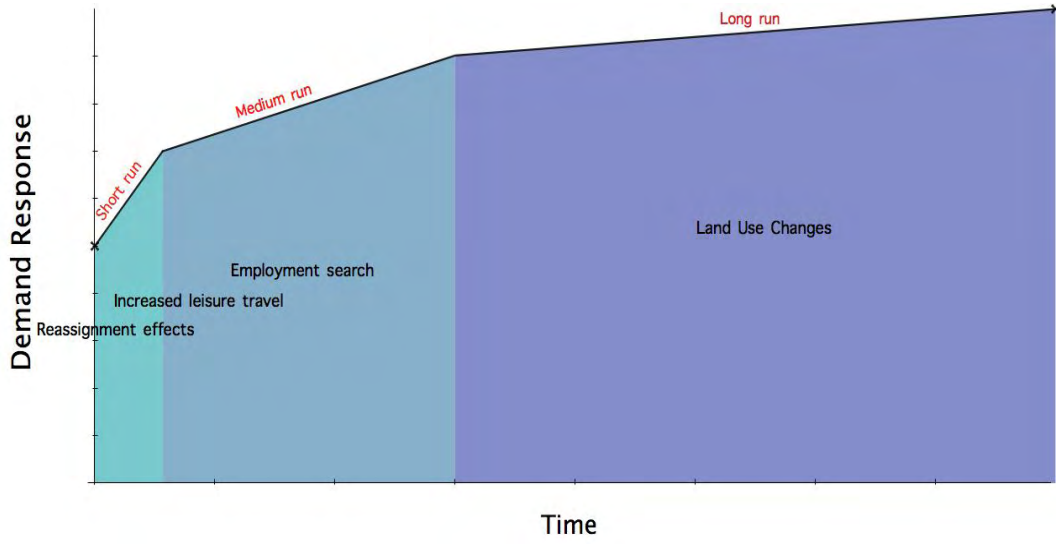
User specific factors:

- Journey purpose – some journeys are more critical or time sensitive than others. On average, business travellers tend to have a higher value of time than leisure travellers. Travel on work time / employers time have a higher value of time than trips taken in personal time and are likely to be less sensitive to tolls;
- Length of trip – for longer trips, tolls will make up a smaller proportion of overall journey costs. Therefore, those on longer journeys will be less sensitive to tolls which will have a more marginal effect on total journey costs. Equally, the longer the tolled route the less influential the toll;
- Income – higher income users will be, on average, less sensitive to toll costs; and
- Vehicle occupancy – for vehicles with more than one occupant, the cost of the toll is effectively shared between occupants and will therefore play a lesser role in transport choices.

Time based factors:

As noted, some behaviours may adapt over time and the full effect of a change in a tolling regime will not be realised immediately. Empirical studies confirm that short and long term elasticities can differ substantially. It is difficult, however, to determine over what time period different effects will play out in reality.

Figure 5.1 - Illustration of Timing of Toll Scenario Impacts



5.3.1 Implications for the Severn Crossings

Route and Contextual Factors

Although drawn from a relatively small sample, the range of elasticities found for tolled crossings and tunnels worldwide typically lies within the range -0.1 to -0.5, although for tolled roads more generally examples can be found of elasticities significantly below -0.1 and others approaching -1.0. One of the main explanatory factors is the availability of a viable alternative. There is no clear conceptual difference between tolled bridges and toll roads more generally, although in the case of bridges and tunnels it is much more likely that alternative untolled routes will be less 'competitive'.

It is also the case that the traffic on the Severn Crossing is within the capacity of the motorway network in normal conditions, and other than some peak time delays (very often as a result of the toll booths themselves), congestion is slight in comparison with many other stretches of motorway in the UK. The fact that the Severn Crossings are tolled in a single direction is instructive in that it reveals the degree to which users choose to avoid paying a toll by taking alternative routes or by organising round trips such that they avoid the crossings in a westbound direction. Although there is an imbalance in flows, the imbalance is relatively small (less than 5% overall).

User Specific Factors

The M4 is used for a huge range of journey types (for example, freight, business travel, commuting, leisure) and therefore users' (or deterred users') perceptions of tolls will vary greatly depending on the type of trip being taken and their sensitivity to time and cost factors. If generalisations can be made for the Severn Crossings it is that a relatively high proportion of trips will be relatively long distance given the fact that the M4 is a motorway and also because of the distances between major settlements. Furthermore, motorway traffic (as compared to urban routes for example) tends to have a relatively high proportion of goods vehicles and business travellers. Whilst commuting is significant, it is likely to represent a much lower proportion of total traffic than for a tolled route into a city. These factors might suggest a profile of users skewed to less cost sensitive trip purposes.

Other things being equal, the logical inference is that the elasticity on the Severn Crossings could be expected to fall at the lower end of the range found in the literature.

5.4 Modelling Framework

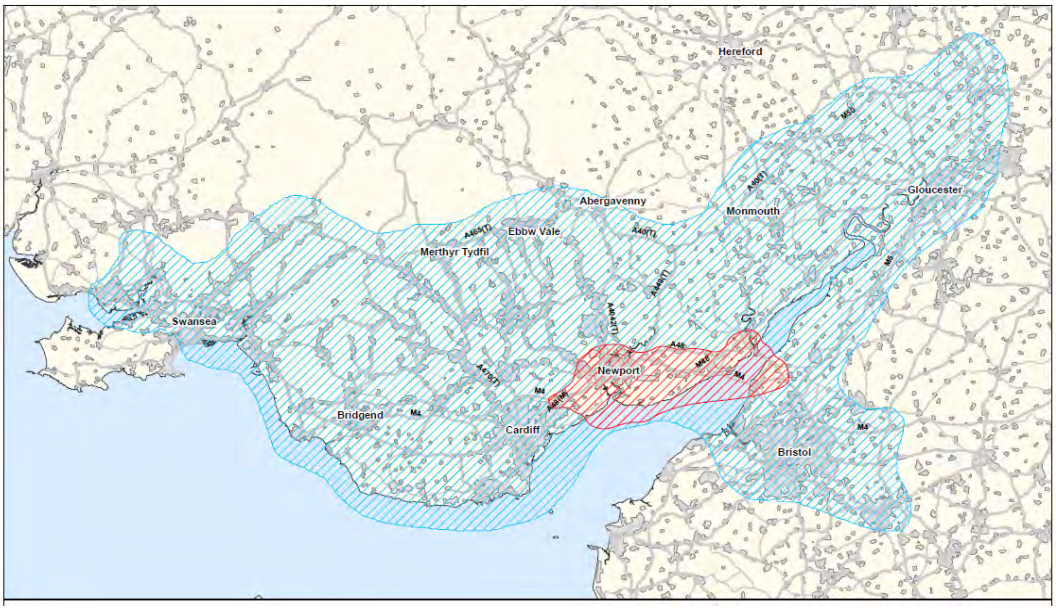
Because tolls have been in place since their opening, there is no reliable historic change in tolling regime on which to base an estimate of the effect of tolling on traffic demand. Furthermore, the lack of a comprehensive literature on toll responses, and the importance of locally specific factors, is such that the most appropriate approach to analysing each of the toll scenarios is a modelled approach.

The M4 traffic model is the primary traffic model used for this study. The model is well suited to this study because of its detail and coverage. The 'core area' of this traffic model covers the strategic highway network in south east Wales to a

high level of detail. This area extends from Junction 30 of the M4 in Cardiff to Junction 21 of the M4 to the east of the Severn Estuary. Outside this core area is a large area of influence that is modelled at a lower level of detail, although even outside this area origins and destinations of vehicles can still be determined at, at least, regional level.

The model has been calibrated for the years 2010, 2018, 2023 and 2028. The current (2010) and future year model has been updated to reflect changes in traffic flows across the bridges since 2005 using count data provided by Traffic Wales.

Figure 5.2 - M4 Traffic Model Coverage (Core and Wider Area)



5.4.1 Modelling Process

There are two elements within the traffic model through which changes in transport costs and journey time are represented. The first element is the assignment module which calculates the most efficient (least costly) route through the network for travel between any origin and destination. The second element is the demand module, which predicts changes in demand for travel between any two origins and destinations based on the cost of travel. Tolls affect both the assignment module (by making the tolled route more costly relative to other routes) and the demand module (by increasing the costs of travel between origins and destinations which are affected by the toll).

It should also be noted that the traffic model takes into account any effect of tolling on the level and flow of traffic. For example, if tolls are reduced, this may have the effect of increasing the level of traffic on the tolled route or other routes (due to some combination of demand and assignment effects) which could in turn reduce traffic speeds (due to increased congestion), leading to increased travel times. Therefore, all other things being equal, changes in demand due to tolls will be (at least partly) offset by higher or lower congestion.

5.4.2 Tolls and Transport Costs

Total transport costs for road users are comprised of fuel costs, vehicle operating costs (tyre wear for example), fares or toll costs, in addition to the opportunity cost of lost working or leisure time. To calculate the total costs of transport, financial costs and time related costs need to be converted into a consistent unit, in this case 'generalised time'. This requires an understanding of the relationship between time and costs, in other words user's Value of Time (VOT).

The effect of the tolls on the behaviour of users can only be assessed by considering toll costs alongside other costs. The 'penalty' for trips crossing either of the Severn Bridges is applied as the effect of the toll on the generalised time of travel. A further delay is imposed on users to reflect toll booth stop-start delay, although this delay can only be approximated from past observations.

As noted, traffic responses are highly complex and different road users will react differently to changes in the toll. Therefore, values of time, generalised costs of travel and elasticities of demand in response to transport costs have been estimated for a total of 14 different types of user based on vehicles type, trip purpose, distance travelled and income.

Table 5.1 - Values of Time (£s per hour, 2005 values and prices)

Purpose	Trip Distance	Income Band	% of trips (2005 base model)	Values of Time (£s per hour)	Elasticity of Demand (vehicle kms)to transport costs (Inter-Peak Period)
Commuters	Short	low	27%	£4.14	- 0.13
		high	29%	£6.48	- 0.10
	Long	low	21%	£4.14	- 0.24
		high	22%	£6.48	- 0.08
Business / Work Trips	Short	low	26%	£15.49	- 0.42
		high	45%	£19.98	- 0.39
	Long	low	11%	£27.32	- 0.47
		high	18%	£35.20	- 0.44
Other / Leisure	Short	low	7%	£4.38	- 0.31
		high	4%	£5.36	- 0.28
	Long	low	57%	£4.38	- 0.54
		high	32%	£5.36	- 0.35
LGV			100%	£8.94	- 0.34
HGV			100%	£8.94	- 0.33

Source: Arup M4 Traffic Model

5.4.3 Empirical Basis

Transport Costs

The values of time employed in the model are based on two sources: Department for Transport recommended values of time for various categories of road user

which are weighted by values of time derived from a 2005 Stated Preference (SP) survey undertaken to assess the potential demand for a proposed tolled M4 relief road around Newport. The SP survey asked drivers to choose between various scenarios for a tolled M4 relief road. Respondents were asked to choose between paying to use a toll road or remaining on the untolled road network and suffer the penalty of a longer journey. In effect, the SP survey estimates user's willingness to pay for time savings, or their value of time. A further adjustment has been made to the value of reflect average wage rates in the 'Severnside' area. This ensures that the model reflects, as much as possible, users of the M4 specifically.

Elasticity of Demand

The overall response to changes in toll costs (or indeed generalised costs) incorporates and simplifies a complex range of user choices and responses including trip frequency, trip distribution and mode choice. The traffic model needs to be calibrated such that the elasticity of demand (total vehicle kilometres travelled) to transport costs reflects available empirical evidence on the sensitivity of traffic demand to changes in fuel prices. This implies that a pound saved on toll costs will have an equivalent impact on demand as a pound spent on fuel costs.

Rational vs Psychological Toll Response

There are disadvantages of the approach set out above. In particular, it imposes a degree of rationality on the responses of users and the influence of driver's perceptions of tolls is not reflected in the demand responses. The psychological response to tolls is highly complex. It is often suggested that motorists, particularly in the UK, perceive roads to be a resource which is paid for through taxation and road tax. This results in an unwillingness to pay tolls even where paying the toll would appear to be the rational response. This effect may be further reinforced by the fact that tolls tend to be paid in cash, directly 'out of the drivers pocket', whereas other costs (time, fuel, vehicle depreciation) are much more difficult for drivers to calculate. In the case of the Severn Crossings, tolls have been in place since construction, bringing the possibility that users now perceive tolls to be the normal state of affairs. If this is the case then a reduction or removal of the toll would be perceived as a 'gain' without any additional weight placed on it.

The importance of the above factors in shaping the responses of users to tolls is likely to differ across alternative user types or trip purposes. For example, drivers who use the crossings on a regular basis (most obviously commuters) could be expected to make a more calculated assessment of the cost of the toll than in-frequent users. Commuters, for example, will set the cost of the toll against their wage and would factor this into employment decisions. Freight operators, particularly those with vehicles making frequent trips, are another example of a group who would be more likely to make rational choices about the relative costs and benefits of toll payment, given that logistics firms tend to operate in highly competitive markets and often make detailed calculations of journey costs. The response of business travellers is likely to depend to a great extent on who pays the toll – the employer or the employee. In most cases the employee is likely to claim back the cost of the toll payment from the employer and therefore could be relatively insensitive to toll costs.

Given that there is no systematic method or empirical basis for determining the significance of the influence of users' perceptions of tolls, it is considered that assuming equivalence between toll and fuel price elasticities is a reasonable approach.

5.5 Impacts of Traffic Flows

A high level traffic analysis has been undertaken for each of the scenarios for the years 2018, 2023 and 2028. These provide approximate estimates of changes in traffic flows resulting from each scenario, based on the assumptions set out above. It should be noted that the traffic forecasts do not take into account the effect of recent or potential future policies which will affect traffic flows on the M4 (for example the recent introduction of Variable Speed Limits on the M4).

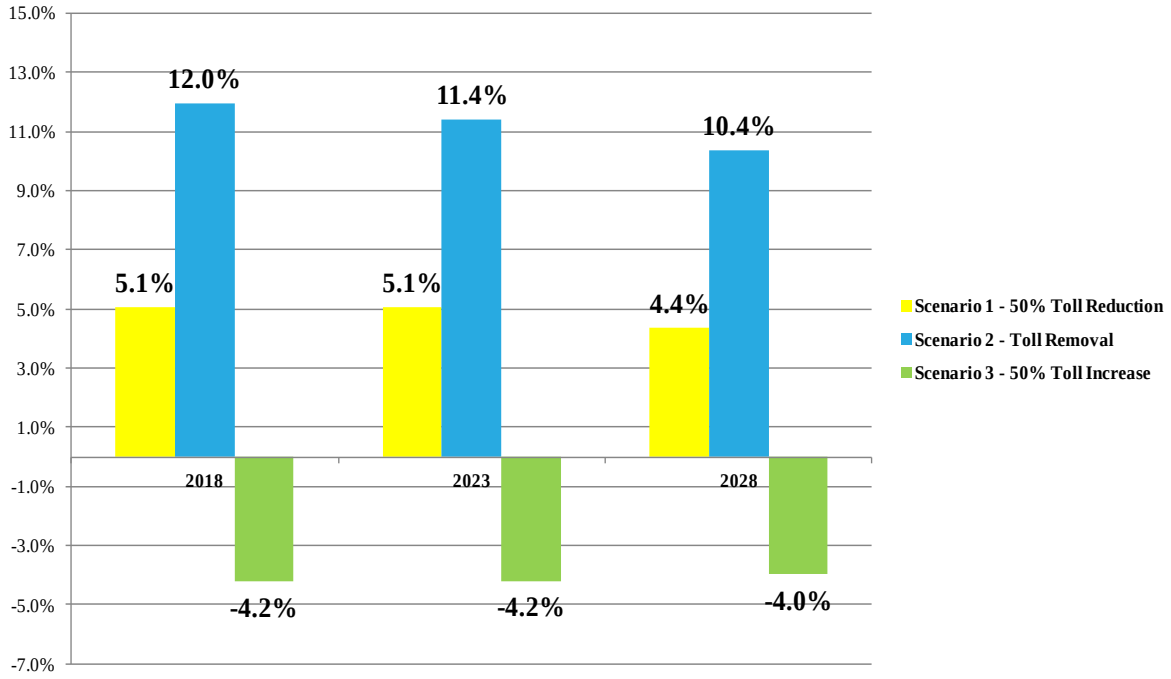
Another important consideration in interpreting the results of the traffic model is that the model provides a static representation of dynamic effects. The traffic model simulates effects as if all users have perfect knowledge and with no lag time in the adjustment of behaviour. The elasticities, which determine the response predicted by the model, are based on behavioural responses to changes in transport costs which have been observed over time. Therefore, the given change in traffic flows for each year could, in effect, be considered a long run response. As illustrated in Figure 5.1, the long run response will be realised over time, rather than as a step change implied by the traffic model.

5.5.1 Overall Traffic Response

The headline results under each scenario are given for total traffic levels, in both directions combined and for both crossings combined. Reducing the tolls by 50% would result in an increase in total traffic estimated to be in the order of 5% based on predicted conditions in 2018. Removing the tolls entirely and eliminating any toll collection delay would result in an increase in traffic of 12%. This is equivalent to around 11,000 vehicles per day.

An increase in the toll of 50% would reduce traffic by around 4%. The elastic response to a 50% reduction in the toll is slightly less than half of the response to complete removal. This is linked in part to the elimination of the toll booth stop-start delay.

Figure 5.3 - Effect on Total Severn Crossing Traffic Flows by Scenario



Source: Arup M4 Traffic Model

Over time, the difference between the level of demand in the tolled scenarios from the base falls. For example, for toll removal, the difference between untolled and tolled traffic flows falls from 12% in 2018 to around 10% in 2028. This is due to the cost of the toll falling as a proportion of total journey costs, primarily due to higher values of time and rising fuel costs, but also as a result of slower journey times in the future due to higher baseline levels of traffic.

Table 5.2- Overall Traffic Response (Average Annual Daily Traffic)

Scenario		2018	2023	2028
Baseline – Existing Tolls	Vehicles (eastbound and westbound combined)	91,921	98,233	102,673
Scenario 1 - 50% Toll Reduction	Vehicles	96,576	103,217	107,158
	% Change on baseline	**5.1%**	**5.1%**	**4.4%**
Scenario 2 - Toll Removal	Vehicles	102,913	109,446	113,341
	% Change on baseline	**12.0%**	**11.4%**	**10.4%**
Scenario 3 - 50% Toll Increase	Vehicles	88,039	94,115	98,580
	% Change on baseline	**-4.2%**	**-4.2%**	**-4.0%**

Source: Arup M4 Traffic Model

As shown in Table 5.3, the inferred effective overall elasticity with respect to the toll in 2010 is between -0.08 and -0.12. This places the Severn tolls within the range of estimates found in the literature, albeit at the lower end. As discussed above, the lack of feasible alternative routes and the fact that the M4 is an inter-urban motorway would suggest that the estimated traffic response is reasonable.

Table 5.3 - Inferred Point Elasticity[20]

Inferred elasticity	2018	2023	2028
Scenario 1 - 50% Toll Reduction	-0.10	0.10	0.09
Scenario 2 - Toll Removal	0.12	0.11	0.10
Scenario 3 - 50% Toll Increase	0.08	0.08	0.08

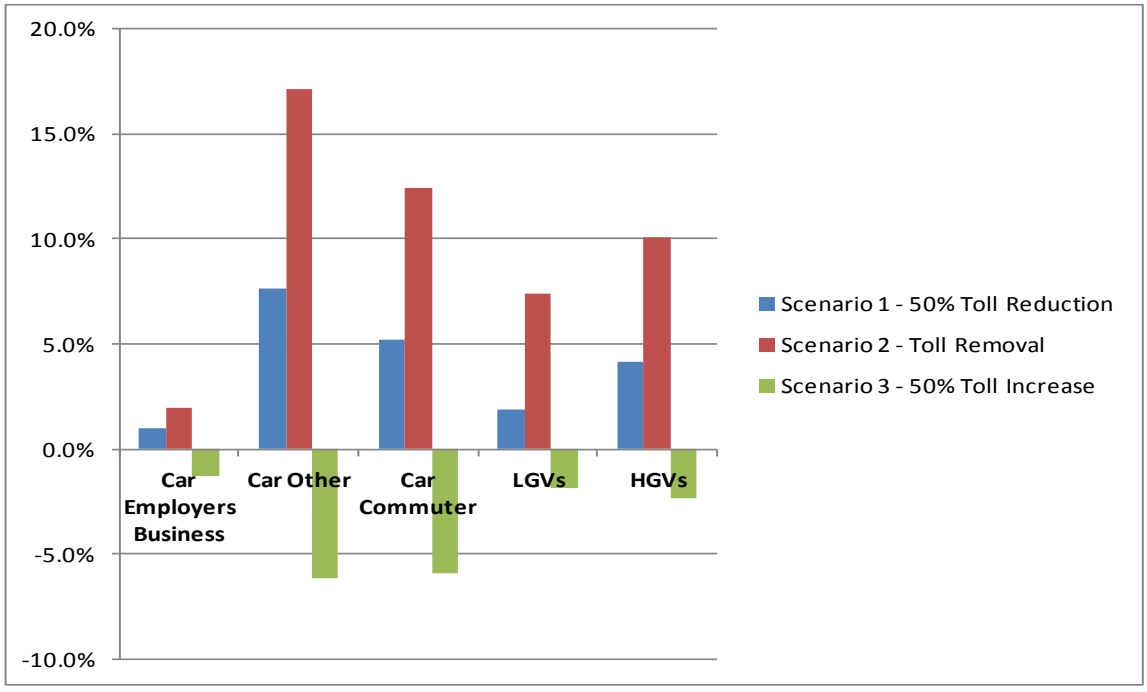
Source: Arup M4 Traffic Model

5.5.2 Traffic Response by User

The total traffic response is made up of the responses of a complex range of responses of different users. The traffic response can be broken down such that the effect on each type of vehicle or user can be analysed.

As would be expected, business users are much less sensitive to the toll than other car users (commuting, leisure and other trips), mainly because the former place a high degree of importance on travel time, but also because the profile of users is more heavily weighted towards higher income users on longer journeys. For goods vehicles, LGVs and HGVs, the response is slightly above average.

Figure 5.4 - Change in Severn Crossing Traffic Flows by User Class



Source: Arup M4 Traffic Model

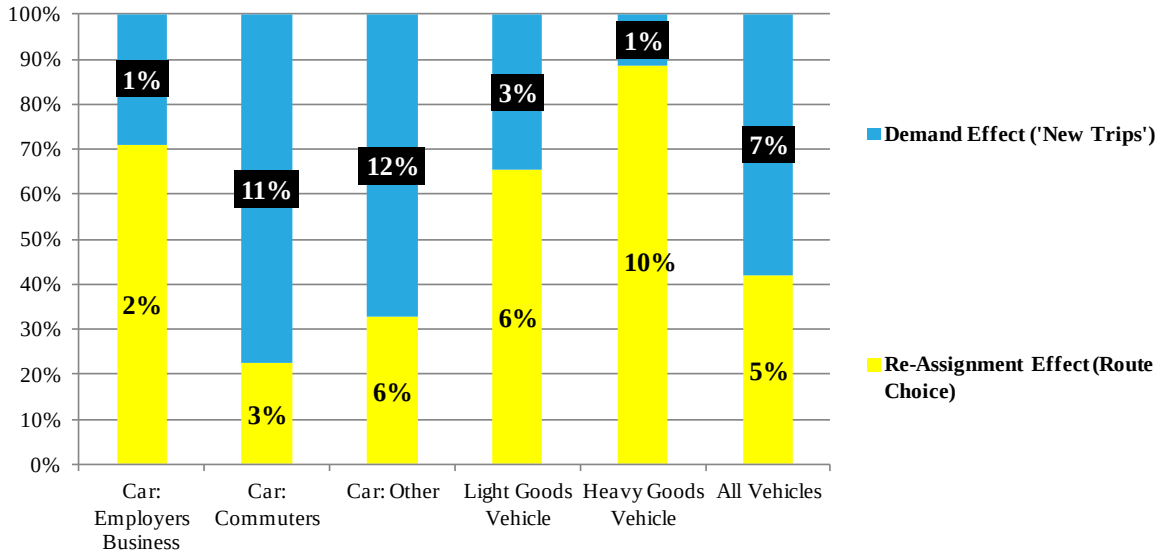
It is important to understand the factors influencing the overall traffic response. In particular it should be recognised that the change in traffic flows is comprised of a 'demand effect' and a 'reassignment effect'. Under the toll reduction or removal scenario, reassignment effects represent trips using the Severn Crossings that would otherwise have taken alternative routes through the road network. The demand effect represents 'new' trips that would not otherwise have taken place (by road) because the toll is reduced or removed.

[20] Calculated as the % change in traffic divided by the % change in the toll price.

For the Severn Crossings, the demand effect is dominant, but notably only for some road user types. Overall, only 58% of the increase in traffic or around 6,000 trips per day, if tolls were removed, is due to changes in the demand for travel. The remainder of the traffic response relates to drivers taking alternative routes through the network choosing, for example, to use the M4 rather than the M50. Reassignment effects are likely to be much more important for the M48 motorway than for the M4.

For time sensitive users, such as business users, the change in traffic flow is primarily due to reassignment rather than changes in demand. It is particularly interesting that the model predicts a very small change (around 1% of the total response) in overall demand for heavy goods vehicles (for which time costs and vehicle operating costs are high). The model suggests that a significant proportion of HGVs are currently influenced by the toll to avoid the M4 or M48 and take alternative, untolled routes. This fits well with evidence from the M6 toll road as well as evidence provided to this study by logistics operators.

Figure 5.5 - Demand versus Re-assignment Effects



Source: Arup M4 Traffic Model

5.5.3 Effects on the M4 and M48

The change in traffic resulting from changes in the toll is greater for the M48 Severn Bridge than for the M4 Second Severn Crossing. There are likely to be a number of reasons for this. Firstly, the profile of users on the M48 is more skewed towards commuting and leisure journeys. Secondly, journeys using the M48 are typically much shorter than for the M4. Also, the offsetting effect of higher/lower congestion is likely to be much less significant for the M48 than the M4.

Table 5.4 – M4 and M48 Overall Traffic Response

		M4 Second Severn Crossing			M48 Severn Bridge		
Scenario		**2018**	**2018**	**2018**	**2018**	**2023**	**2028**
Baseline – Existing Tolls	Vehicles	68,710	73,736	77,113	22,062	23,459	24,476
Scenario 1 - 50% Toll Reduction	Vehicles	72,320	77,135	80,296	24,050	25,404	26,332
	% Change	5.3%	4.6%	4.1%	9.0%	8.3%	7.6%
Scenario 2 - Toll Removal	Vehicles	76,889	81,850	85,156	25,704	27,196	28,267
	% Change	11.9%	11.0%	10.4%	16.5%	15.9%	15.5%
Scenario 3 - 50% Toll Increase	Vehicles	65,966	70,709	74,248	20,519	21,858	22,950
	% Change	-4.0%	-4.1%	-3.7%	-7.0%	-6.8%	-6.2%

Source: Arup M4 Traffic Model

Table 5.5- M4 and M48 Response by User Class

User Class	**2018**		**2023**		**2028**	
	M4 Second Severn Crossing	**M48 Severn Bridge**	**M4 Second Severn Crossing**	**M48 Severn Bridge**	**M4 Second Severn Crossing**	**M48 Severn Bridge**
Car Employers Business	6.5%	5.1%	7.0%	6.2%	5.9%	7.7%
Car Other	16.2%	22.4%	10.1%	22.5%	9.5%	21.5%
Car Commuter	11.6%	18.6%	13.2%	17.2%	13.4%	16.1%
LGVs	19.2%	17.5%	13.7%	16.3%	13.6%	15.1%
HGVs	12.8%	9.6%	16.3%	7.4%	14.9%	9.4%
TOTAL	11.9%	16.5%	11.0%	15.9%	10.4%	15.5%

Source: Arup M4 Traffic Model

5.5.4 Financial Implications

The effect of each of the scenarios on the revenue accruing from the toll has been estimated. Toll revenue is published in the annual accounts of Severn River Crossings PLC. Revenue in 2010 (excluding VAT) was £76m. A year on year increase in revenue might be expected although demand is forecast to grow at a relatively slow rate, in real terms, over the next few years. All revenue would be foregone if tolling were to cease. Based on 2010 revenue and applying the changes in demand for each type of vehicle, the reduction in revenue if the toll were halved would be £35m, a 46% reduction. An increase in the toll of 50% would result in additional revenue of around £31m, 41%. In each case, the change in revenue is less that proportional to the change in toll because of the offsetting effect of higher or lower traffic flows.

Under the concession agreement, SRC plc is required to maintain the two bridges, although the Highways Agency is liable for repair of 'latent defects'. Once the concession agreement ends and the costs of financing the construction of the Second Severn Crossing is paid off, the net return on tolling will be the level of

revenue, less the costs of maintaining the bridges[21]. Maintenance costs are difficult to estimate because whilst some maintenance works (for example painting) might be undertaken on an annual basis, other maintenance works (re-surfacing or structural works) are required less frequently but involve high costs.

As an indication, evidence provided by SRC plc to the Welsh Affairs Committee inquiry into the Severn Crossing Tolls suggests that approximately £15m is spent on operating and maintenance each year, of which a proportion will relate to toll collection costs. Therefore, a simple net operating profit (before tax and excluding any finance payments) is approximately £60m. To put these sums into some perspective, the Welsh Government's revenue budget for 2012/13 for 'Improving Domestic and International Connectivity' totals £341m.

Table 5.6 - Impact on Toll Revenue

	% Change in Revenue (2018)	Approx Revenue Lost / Gained (based on 2010 revenue)
Scenario 1 – 50% toll reduction	-46%	-£35m
Scenario 2 – Toll removal	-100%	-£76m
Scenario 3 – 50% toll increase	+41%	+£31m

Source: Arup M4 Traffic Model

5.6 Network Wide Effects

The estimated changes in traffic under each of the alternative tolling scenarios factor in a response to changes in travel time and costs due to increased or reduced congestion. Hence, the overall effect of changes in the toll is, to some extent, slightly offset by congestion effects. The effects of removing the toll on traffic flows and speeds on the network have been modelled under normal conditions during the morning and evening peak periods (7am – 10am and 4pm to 7pm). This is a high level analysis and no allowance has been made for the effect of traffic management measures recently introduced to the M4 or other current or future Welsh Government measures on this corridor.

An illustration of the effect of removing the tolls on traffic conditions on the rest of the network is provided in Figures 5.6 and 5.7. Given that the toll is collected in the westbound direction, changes in traffic flows and speeds are much more pronounced on the westbound carriageway on both bridges and further along the M4. Whilst the change in traffic flows is highly significant – an 18% and 16% increase on the westbound carriageway of the M4 and M48 respectively – the change in traffic speed is only -0.1 to -0.2 miles per hour on average. This is because the crossings themselves operate well within capacity.

Based on the average values of time built into the model (for all trip purposes), the financial benefit of no longer paying the toll far outweighs the disbenefit of the predicted increase in congestion. However, it should be noted that removing the toll would have a negative effect on drivers and journeys that do not use the Severn Crossings. The net costs and benefits across the network as a whole have not been calculated.

[21] It might also be considered that the rationale for continuing to toll is to build up savings in the event that one of the crossings requires replacement in the future.

The percentage change in traffic due to the removal of the toll reduces markedly after Junction 23 and 24. This reflects the fact that shorter journeys (with an origin or destination in places such as Chepstow, Monmouth and Newport) are more likely to be deterred by the toll than longer distance trips. At the Brynglas tunnels, the increase in traffic is just 2%. However, the change in traffic speed resulting from this is as much as 12%. Whilst this is only around 4 miles per hour, it should be noted that this analysis reflects average conditions. The effect during highly congested periods would be expected to be much greater.

The analysis highlights the fact that the traffic effects of removing the toll are more likely to be felt away from the bridges themselves. Furthermore, it highlights the very significant capacity constraint at the Brynglas tunnels.

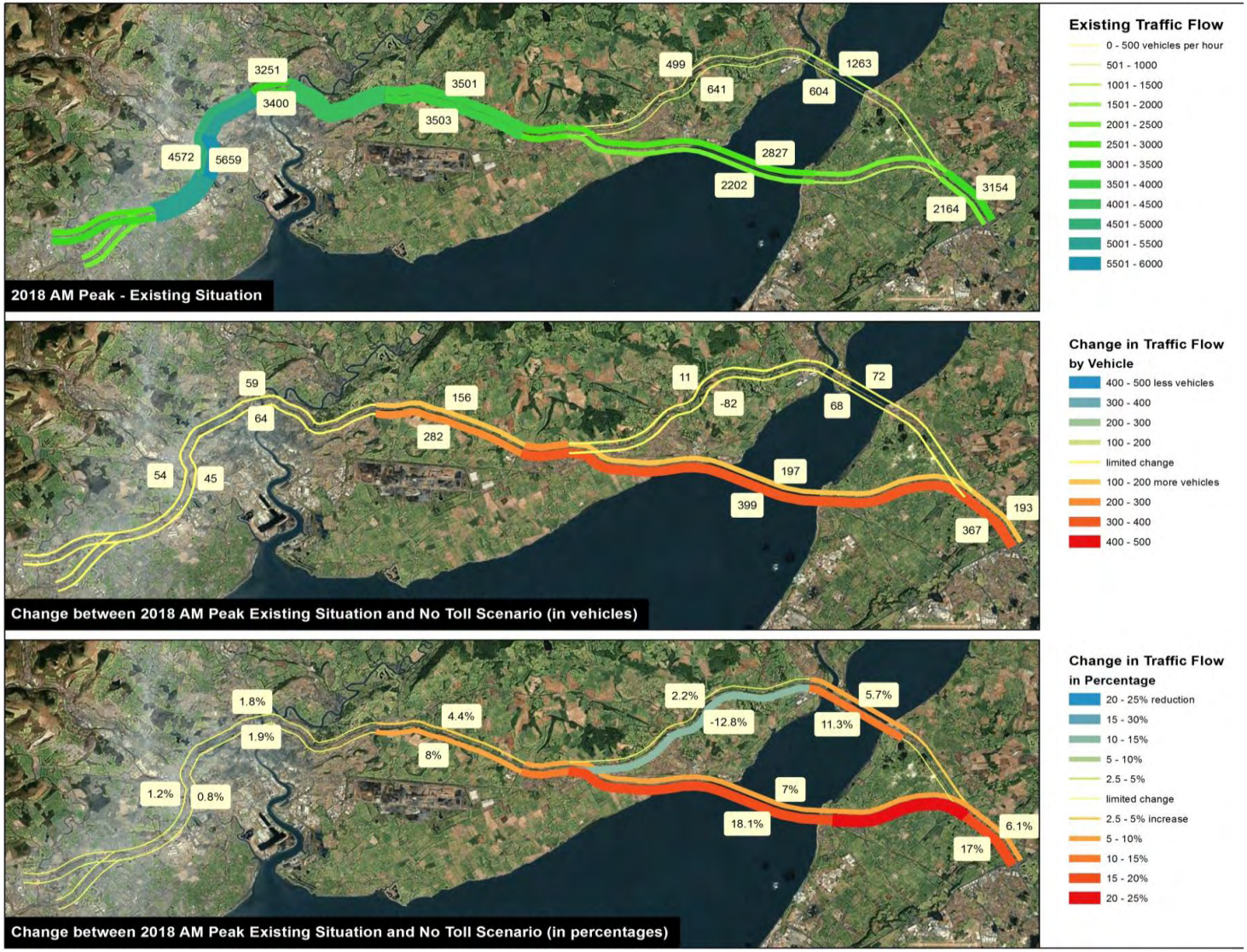


Figure 5.6- Traffic Flows, Vehicles Per Hour - Baseline and Tolls Removed

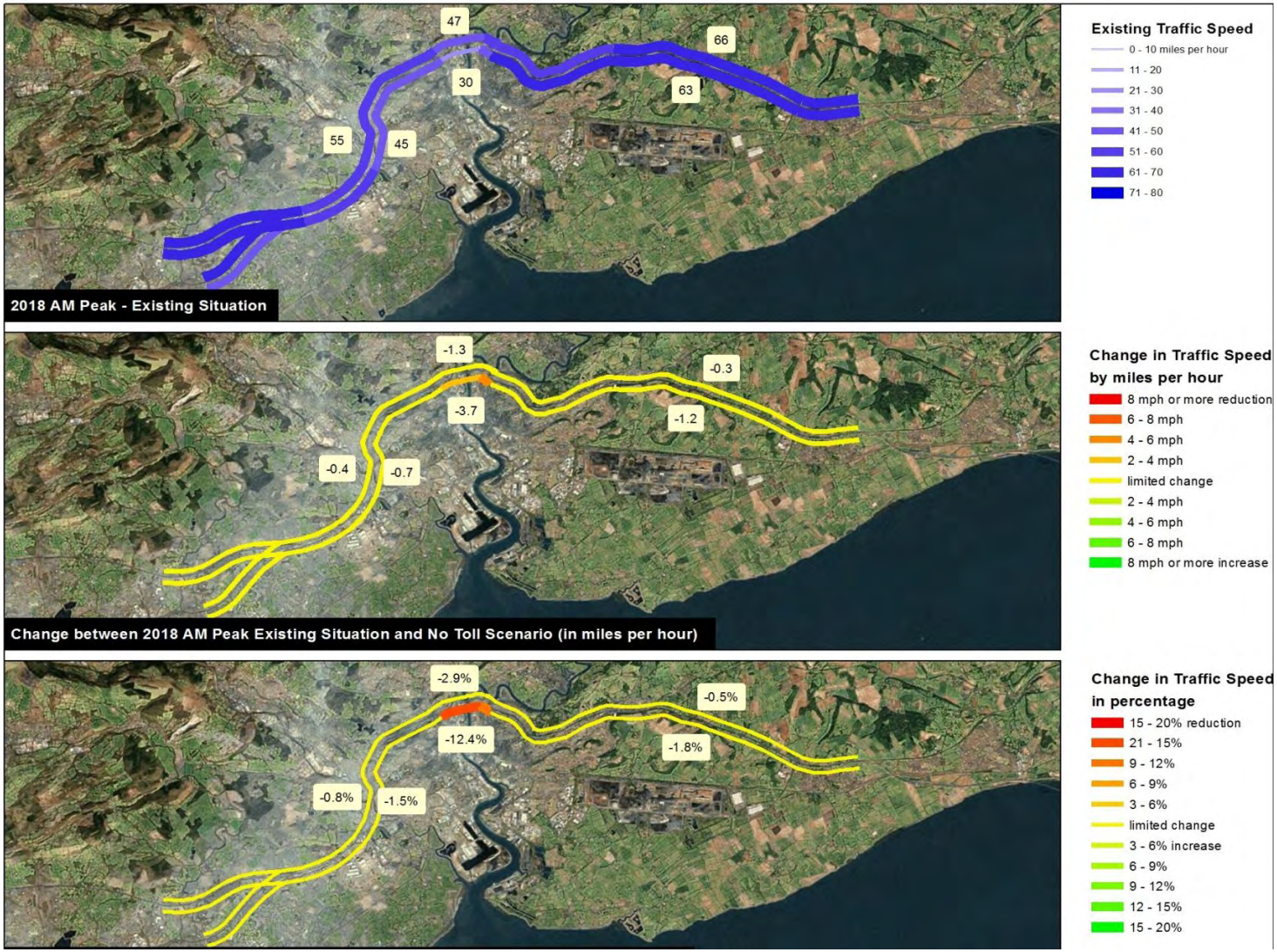


Figure 5.7 - Traffic Speeds - Baseline and Tolls Removed

5.7 Environmental Impacts

Tolls suppress demand for road travel and therefore have a reducing effect on the total level of emissions. It should be noted, however, that the reduction in emissions resulting from lower demand for road travel is slightly offset by a small proportion of vehicles taking alternative and typically longer routes. In the case of HGVs, the tolls actually increase emissions because the reduction in demand is more than offset by an increase in distances travelled due to the use of longer alternative routes. There is also a small negative effect on emissions of the stop-start delay imposed at the toll booth.

The actual net change in emissions due to tolling is difficult to calculate precisely due to the fact that part of car journeys (for example on minor roads) is not captured by the traffic model. However, Table 5.7 shows the change in emissions occurring within the core and wider area of the traffic model under alternative tolling scenarios. Emissions are measured on a per hour basis for the average day. The change in emissions reflects traffic speeds as well as volumes.

Tolling is estimated to reduce emissions by around 70 tonnes per year. Despite a 12% reduction in traffic over the bridges, this represents around 1% of emissions captured in the traffic model. Therefore, the tolls save only a small fraction of Wales total carbon emissions from road transport. In the context of the Welsh Government's target for emissions reduction of 0.29 million tonnes of CO_2 in the transport sector from Welsh Government policies, the saving is considered to be relatively small.

Table 5.7 - Impacts of Scenarios on Carbon Dioxide Emissions (Tonnes Per Annum)

Scenario	Measure	Cars	LGVs	HGVs	Total
Baseline Forecast	Absolute emissions in 2018	6,170	478	761	**7,410**
50% Reduction in Tolls	Change against baseline forecast in 2018	26.5 (0.4%)	0.9 (0.2%)	-2.0 (-0.3%)	**25.4 (0.3%)**
Tolls Removed		69.1 (1.1%)	2.2 (0.5%)	-1.0 (-0.1%)	**70.3 (0.9%)**
50% Increase in Tolls		-21.9 (-0.4%)	-0.6 (-0.1%)	0.7 (0.1%)	**-21.8 (-0.3%)**

Source: Arup M4 Traffic Model

Although carbon emission is the only environmental impact to have been specifically assessed as part of this study, there are other environmental impacts of higher traffic levels that need to be considered. For example, there would be a corresponding impact on air quality. There are currently nine Air Quality Management Areas (AQMAs) in Newport, two in Monmouthshire and three in South Gloucestershire. Of these AQMAs, four in Newport[22] are located adjacent to the M4 corridor. Should the tolls be removed and traffic levels increase, it would be expected that this would lead to an increase in air pollution. However, this may be partly offset by the elimination of queuing at the toll plazas and the impact of some vehicles (particularly heavy vehicles) ceasing to take longer

[22] Shaftesbury/Cridau, St Julians, Royal Oak Hill and Glasllwch.

alternative routes. This offsetting effect is of particular relevance given the presence of an AQMA in Chepstow adjacent to the A48.

Given this complexity, more detailed research would be required to establish the degree of impact of toll removal on air quality although it would be reasonable to assume that the impact would be broadly proportionate to the overall change in traffic flows. Based on a 12% change in traffic it might be expected that the impact would be relatively minor.

Changes to the tolling may also affect noise pollution. There is evidence of noise pollution along the M4 corridor - the Welsh Government has published maps showing noise pollution on major roads and railways in Wales[23]. Should tolls be reduced or removed and traffic levels increase then noise pollution from the M4 is likely to increase. However, as with air quality impacts, it might be expected that the impact of a 12% change in traffic flows would be relatively minor and that the benefit of diverting traffic away from less appropriate routes would also need to be considered.

5.8 Alternative Policy Scenarios

The scenarios tested above are relatively simplistic. In practice, there are a much broader range of options available to policy makers following the completion of the concession agreement. For example, no consideration has been made here of changes in the relative cost of the toll for different types of vehicle or discounts for regular users. Variable tolls – employing lower off peak charges as a means of reducing congestion – have not been explored as part of this study. Another potential option for the Severn Crossings could be differential tolls across the two bridges which provide a lower cost option for drivers who are willing to suffer slightly increased travel time (by using the M48 rather than the M4) in return for a lower charge.

Furthermore, the end of the concession agreement will provide the flexibility to consider alternative approaches to tolling such as the introduction of technologies which would allow for a greater proportion of users to avoid stopping at the toll booths.

In addition, it should be considered that the forecast traffic flows under the tolled scenarios do not take account of any potential re-investment of toll revenue into transport infrastructure improvements elsewhere on the network which could result in increased capacity, reduced travel times or reduced transport costs.

[23] These can be found at the following link - http://new.wales.gov.uk/topics/environmentcountryside/epq/noiseandnuisance/environmentalnoise/noisemonitoringmapping/majormaps/maps46to50/?lang=en

6 Impacts on Business Performance and Location

6.1 Introduction

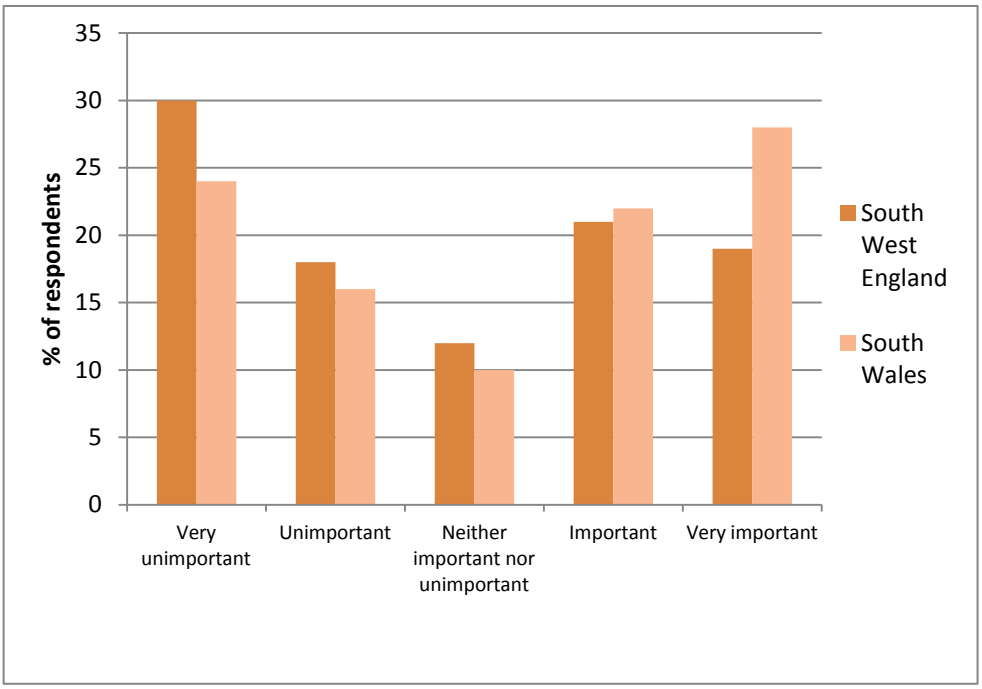
This section presents an analysis of the significance and impact of the Severn tolls on the performance, behaviour and competitiveness of business in South Wales, as well as potential effects on business location. The analysis draws on the responses to the business survey as well as evidence drawn from more in depth interviews and logical debate drawn from the analysis of traffic patterns and transport costs. A total of 451 businesses were surveyed of which 351 were businesses based in South Wales and 100 were businesses based in South West England. The survey was designed such that responses could be analysed separately for business in the transport and logistics sector and all other sectors.

6.2 Impacts on Business Performance

Perceived Significance of the Severn Tolls

That the Severn Crossings are important to businesses in South Wales, both for business travel and for the movement of goods, is confirmed by the results of the business survey. Of those businesses surveyed, 50% considered the crossings to be either 'important' or 'very important' for their business. The relative size of the economies and markets on either side of the bridge determines that the Severn Crossings are of greater importance to the South Wales economy than the English economy. A higher proportion of businesses based in South Wales considered the crossings to be important than those in the South West.

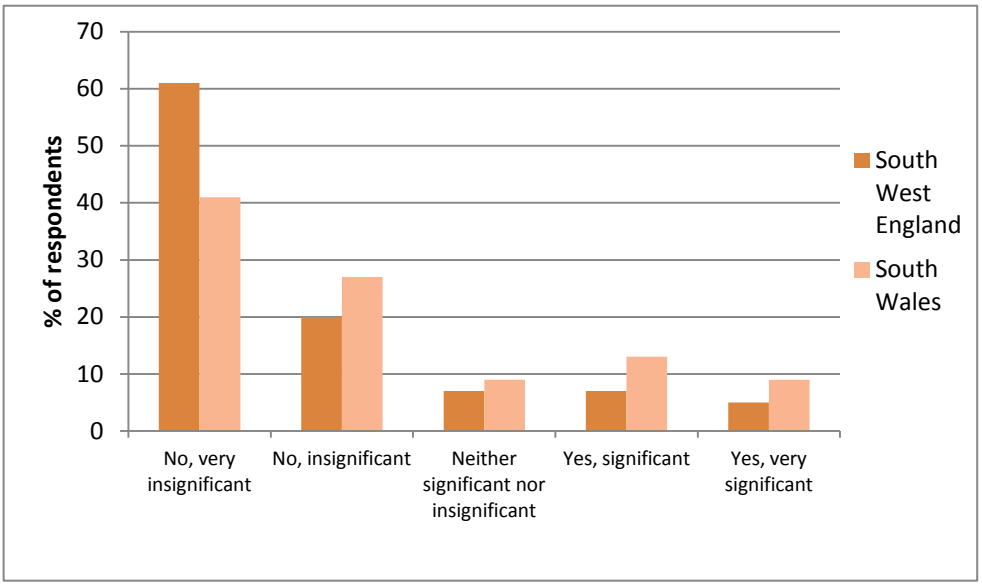
Figure 6.1 Importance of the Severn Crossings for your business (All Respondents)



Turning to the significance of the Severn tolls themselves, the level of importance placed on the tolls differs greatly depending on the nature of the business. The

proportion of businesses for which the Severn tolls are significant is a large minority, with 12% reporting the tolls to be significant and 8% reporting the tolls are highly significant. For the majority of businesses, the Severn tolls are considered a relatively minor issue. The proportion of businesses claiming that the Severn tolls have a significant impact on their business is much less than the proportion that identified the crossings as being significant. Even for those businesses who consider the crossings to be important, only a proportion of these businesses might be considered regular users of the crossings. For example, (excluding transport and logistics businesses) only around 15% of businesses use the crossings more than twice a week for movement of goods or materials[24].

Figure 6.2 – Significance of the impact of the Severn Crossing Tolls on your businesses (All respondents)



Direct Toll Costs

[Can you check that the numbers in this section tally with section 3.5 – at first glance there appear to be a number of differences though there may be a good reason for that and I'm missing it!]Total expenditure on the Severn Crossings tolls (both crossings combined) in 2009 amounted to £77.4m. Although an accurate breakdown is not available, applying survey data suggests that approximately 26% (£19.6m) of the total cost relates to car drivers on work time (business travel), 25% (£19.6m) to drivers travelling to and from work and 25% (£20.4m) to other car trips (leisure trips or other purposes)[25]. Goods vehicles, buses and coaches account for the remainder. Approximately 9% (£6.9m) of total toll revenue relates to light goods vehicles and 14% (£6.9m) relates to heavy goods vehicles.

For the majority of businesses, the direct costs of the Severn Crossing tolls are very small with fewer than 25% of respondents identifying that they spend over

[24] This question relates both to goods arriving and departing. The question does not distinguish between use of the crossings by a businesses' 'own vehicles', however, it should be considered that respondents may be uncertain or unaware of the origin of some goods movements if transported by a third party.
[25] Figures are based on survey data of M4 and M48 users applied to total revenue taken from SRC plc accounts.

£50 per month on toll payments. A total of 46% of firms responded that they spent nothing on tolls, whilst 24% of firms responded that their monthly spend was £50 or more. Therefore, whilst the crossings are considered important to a high proportion of businesses, most businesses spend little on Severn Crossing toll payments directly.

The general pattern is similar for business in the South West of England and South Wales, as shown below, though notably the South West of England had a higher response rate of £0 (53% compared to 44% for South Wales) and lower in the £50 or more category (19% compared to 26% for South Wales). As would be expected, the proportion of businesses for which Severn Crossing toll costs are in excess of £50 per month is much higher amongst businesses within the transport sector.

The real significance of the Severn Crossing toll payments for overall firm profitability will depend on the relative importance of toll costs in total business costs and turnover. For the majority of firms sampled, transport costs account for less than 25% of total business costs. A small number of businesses indicated spending of greater than 75%. For two-thirds of firms, transport costs accounted for less than 9% of total costs. Given that Severn Crossing toll costs typically account for only a small proportion of transport costs (which comprise other costs such as fuel and maintenance) it would therefore appear that the toll costs represent a very low proportion of total costs for the majority of businesses.

Figure 6.3 - Approximate monthly spend by business on Severn Crossing toll payments by geography (All Respondents)

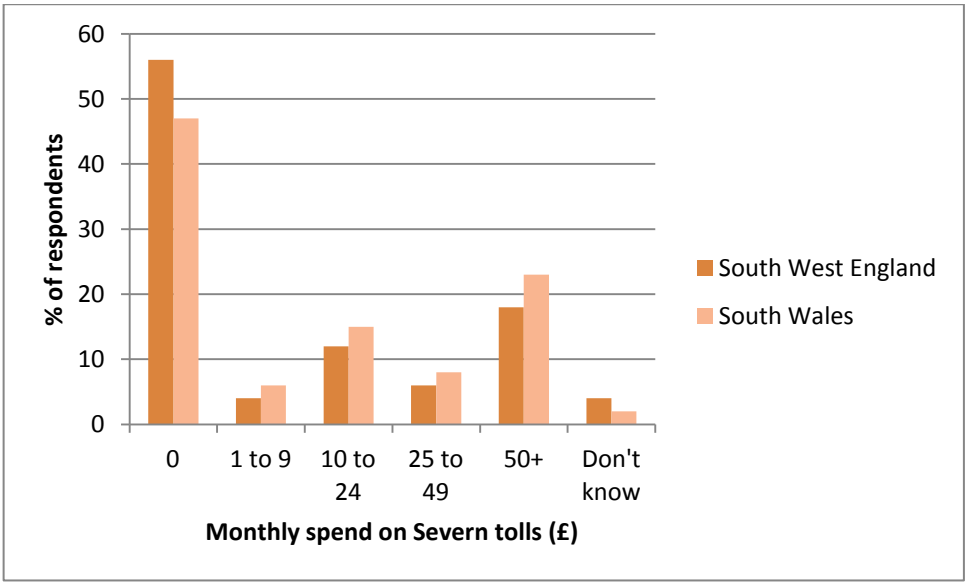
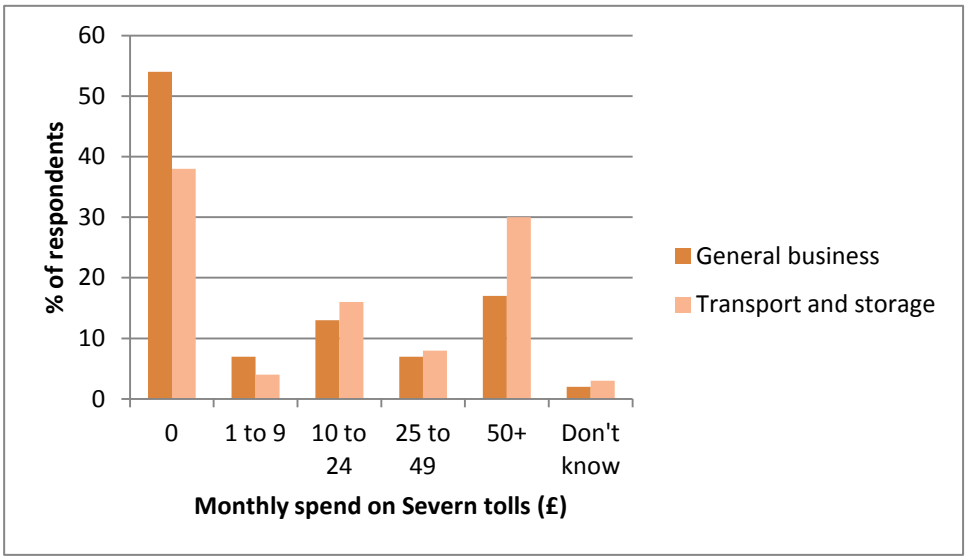


Figure 6.4 - Approximate monthly spend by business on Severn Crossing toll payments by business type (All Respondents)



It should be noted that the total costs to businesses of the tolls relate not only the actual cost of the toll but also the costs which result from businesses (particularly hauliers) from taking alternative and more costly routes. The majority of respondents disagreed that they took alternative routes to avoid the tolls. Traffic analysis showed that vehicles do take alternative routes to avoid paying the tolls but that, for the majority of journeys, this is not a feasible option. Goods vehicles are particularly inclined to take alternative routes and this is discussed further below.

Table 6.1 - Alternative Routes (All Respondents)

Question	Strongly disagree	Disagree	Neither	Agree	Strongly agree
We try to take alternative routes to avoid paying the (Severn Crossing) tolls[26]	49%	29%	8%	10%	5%

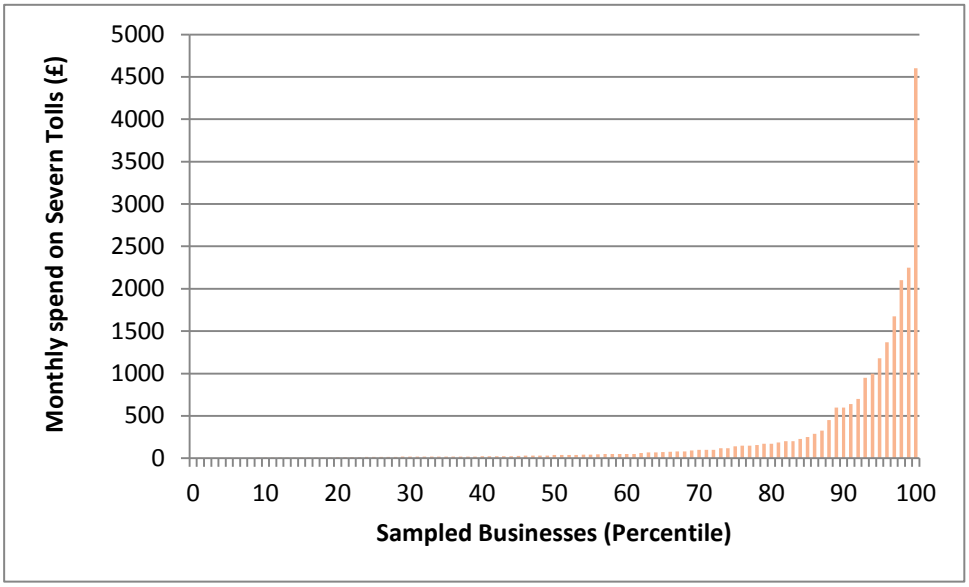
Severn Crossing toll costs for the vast majority of businesses are low. This result is unsurprising given that, for many businesses, transport costs are a small proportion of operating costs and many other outsource transport and therefore would not pay tolls directly. It is more instructive, therefore, to consider the scale of Severn Crossing toll payments at the higher end of the spectrum. For a small cohort of businesses Severn Crossing toll costs are clearly very significant. This is illustrated by the profile shown in Figure 6.5 which shows 5% of businesses spending in excess of £1,000 per month (£12,000 per annum) and one firm reporting average expenditure of over £4,500 per month (£54,000 per annum).

Evidence provided to the Welsh Affairs Committee, as well as media reports[27], suggest that, at the highest end, a small number of businesses spend in excess of

[26] Percentages do not sum to 100 due to rounding.
[27] http://www.bbc.co.uk/news/uk-wales-11719614

£200,000 per year on tolls. This was supported by consultations with representatives of freight operators.

Figure 6.5 - Actual Reported Toll Expenditure Per Month (All Respondents)



A theme of this section, therefore, is the very broad spectrum of views expressed by businesses on the significance of the impact of the Severn Crossing tolls. Unsurprisingly, the importance placed on the tolls is highly specific to the particular sector, location, operating structure of the firm in question, as well as the geographical market within which the firm competes. Based on interviews with businesses, a number of key observations can be made in this respect.

Firstly, for the majority of businesses, whilst the crossings are acknowledged to be important for their business, the significance and the amount spent directly on tolls is relatively small in comparison with total operating costs. However, for a small number of very regular users of the crossings, direct cost can become significant.

Secondly, the survey results indicated that the toll costs were a much more significant issue for manufacturers and transport businesses than for service sector businesses. For service sectors (retail and leisure apart), although the crossings may be used frequently for business travel, toll costs will rarely be a significant part of overall operating costs. The priorities of service sector employers tend to focus on enabling the movement of people through a faster and more reliable road network and good quality public transport links for commuters. Therefore, for these businesses, the benefits of the tolls on reducing congestion on the road network may offset the financial cost of the toll.

Lastly, the importance of payments on the Severn tolls depends on the proportion of toll costs in total operating cost and turnover. For manufacturers, particularly those engaged in high value added activities for example, even if goods and services are moved regularly over the bridge, the cost of the toll per delivery will generally represent a diminishingly small proportion of the delivered price of the goods. Therefore, the focus of the analysis of the impact of the tolls is primarily on transport firms specifically.

Indirect Toll Costs – Cost Pass Through

The direct cost of the toll does not necessarily reflect the actual or final burden of the toll. As noted, a high proportion of surveyed businesses outsourced their transport to other firms. Whilst these businesses will not pay the cost of the toll directly, the cost of the toll may be passed on through higher transport prices and/or higher delivered costs of goods and materials received.

Some proportion of the direct cost of the toll payment could be absorbed by the business paying the toll and a proportion could be passed on to the customer in the form of higher prices. Where toll costs are absorbed, toll costs could reduce the paying firms' profit margin. Where toll costs are passed on, the customer may pay the toll although higher prices may in turn may result in lower demand for the firms' products. The ability of a firm to 'pass on' increased costs will depend on the elasticity of demand for its products. If demand is highly responsive to delivered prices, then firms could be unable to pass on some or all of the toll costs.

The end burden of the toll is complex and difficult to trace. The business survey shows a mixed response but suggests that businesses are more likely to absorb the costs of tolls in their profit margins than to pass on costs to customers. Those firms in the transport sector indicated a greater tendency to pass on toll costs and the issues facing this sector are further discussed below. A large national retailer, consulted separately to the business survey, confirmed that the retail price of goods is set nationally and not varied according to local cost factors such as tolls. This might suggest that the tolls are more likely to affect the price of intermediate goods than consumer goods.

Table 6.2 – Degree to which the Severn Tolls affect businesses (All respondents)

Question	Strongly disagree	Disagree	Neither	Agree	Strongly agree
We pass on all of the cost of toll payments to our customers	38%	21%	9%	15%	17%
We pass on some of the costs of toll payments to our customers	38%	23%	8%	17%	15%
We have to absorb the cost of toll payments	19%	16%	12%	29%	26%

Impacts on Firm's Ability to Compete in Markets

It is important to understand how the additional costs imposed by the toll affect the ability of Welsh businesses to compete. If higher costs results in a lower market share for Welsh businesses then the indirect effect of the toll could exceed the direct cost of toll payments. As outlined above, it should be noted that for the vast majority of businesses surveyed, toll payments are a very small proportion of total costs and therefore effects on competitiveness would in general be expected to be equally small. Furthermore, it should also be considered that if tolls act as a barrier for Welsh firms seeking to access markets in England, logically the tolls

also act as a barrier for firms based in England seeking to access markets in South Wales.

In line the analysis of cost pass through, the business survey shows that more firms are more likely to *report* that tolls affect their costs than they are to report that the tolls deter customers. Nearly a third of businesses suggest that tolls result in higher costs for goods and raw materials. In contrast, only 11% believed that the tolls actual deter customers from purchasing their product This would suggest that a significant proportion of businesses absorb the cost of the toll within their profit margin rather than adjusting their prices and suffering reduced market share. However, it should also be considered that the difference in the responses to these questions could also be linked to the fact that the direct costs of the toll are more 'visible' than indirect effects on customers.

A reasonably high proportion of business (22%) reported that the tolls put their business at a competitive disadvantage compared to those located in England, although it is possible that responses to this question reflect, to some degree, the perceived unfairness of the tolls.

Table 6.3 – Degree to which the Severn Tolls affect businesses (All Respondents)

Question	Strongly disagree	Disagree	Neither	Agree	Strongly agree
We pay more for goods or raw materials because of the tolls	33%	25%	12%	22%	10%
The tolls deter customers from visiting our business	44%	32%	8%	11%	5%
The tolls deter customers from purchasing out products / services	47%	34%	8%	8%	3%
Our business is at a disadvantage compared to competitors in England/ Wales because of the tolls	40%	30%	8%	11%	12%

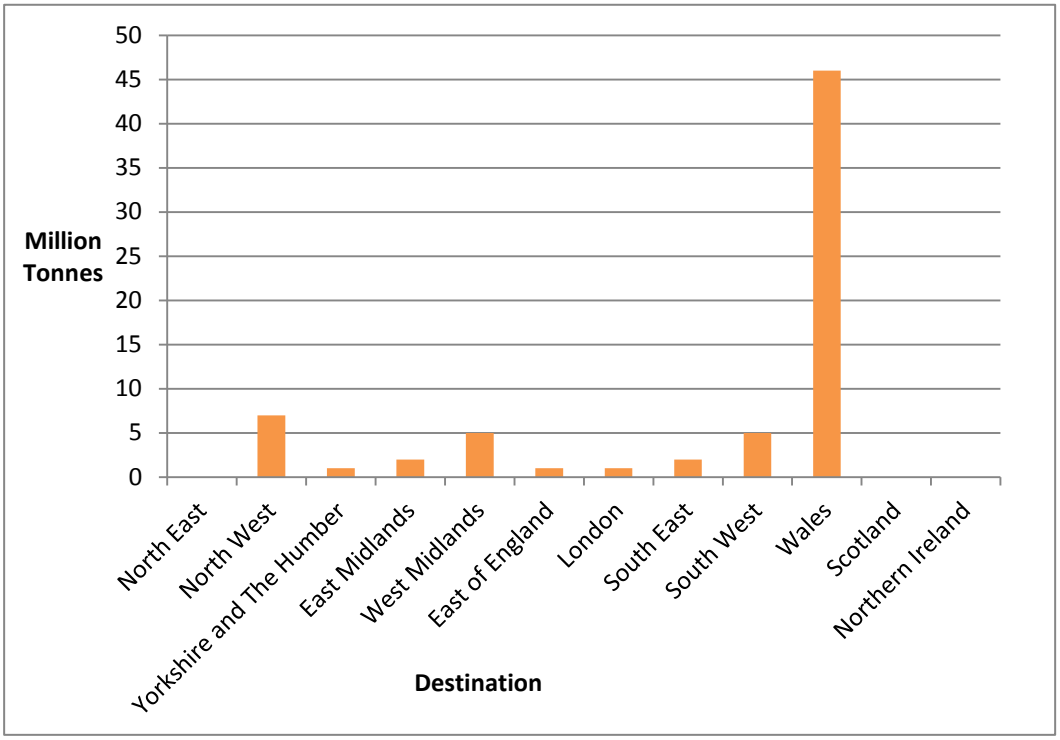
6.3 Impacts on the Transport and Logistics Sector

Significance of Toll Costs for Logistics Firms

The preceding analysis makes clear that the impact of the tolls is much more significant for the transport and distribution sector than for the economy as a whole. Firms in this sector are much more likely to report that the tolls have a significant impact on their businesses, although it should be noted that even within the transport sector the importance of the tolls depends on the specific operations of the firm in question and, in particular, the degree to which they are engaged in cross-border transport. Moreover, the proportion of the cost of a freight movement accounted for by the cost of the toll will diminish with distance. For long distance haulage, wage and fuel costs will quickly erode the significance of the toll.

The type of goods transported and characteristics of individual firms' operations are also significant. Transport of low value goods is likely to be more affected than transport of high value goods. 'Just-in-time' hauliers value journey times, but for the most part hauliers can avoid congestion by travelling at different times, therefore the effect of the toll on reducing congestion is not highly valued by hauliers.

Figure 6.6 - Destination of Goods Originating in Wales by Weight



Source: DfT, Road Freight Statistics

In other parts of the transport sector, the importance of tolls is heightened because profit margins are typically very low. The industry is extremely competitive and the effect of the economic downturn combined with fuel price increases has eroded profit margins further to the extent that margins are less than 3% in many cases[28]. Therefore, whilst the toll may be a small proportion of the cost of a freight movement, it could make a significant difference to the profit margin of the job in question. Whilst businesses can, and do, mitigate against tolls through the use of alternative routes, this has a cost in itself in terms of higher wage costs and fuel costs. The survey evidence suggests that around one quarter of firms try to take alternative routes to avoid the tolls and the traffic data confirms that this is a feasible option only for a small subset of journeys. Evidence from elsewhere (M6) also suggests hauliers are sensitive to toll costs and avoid tolls even when faced with higher journey times.

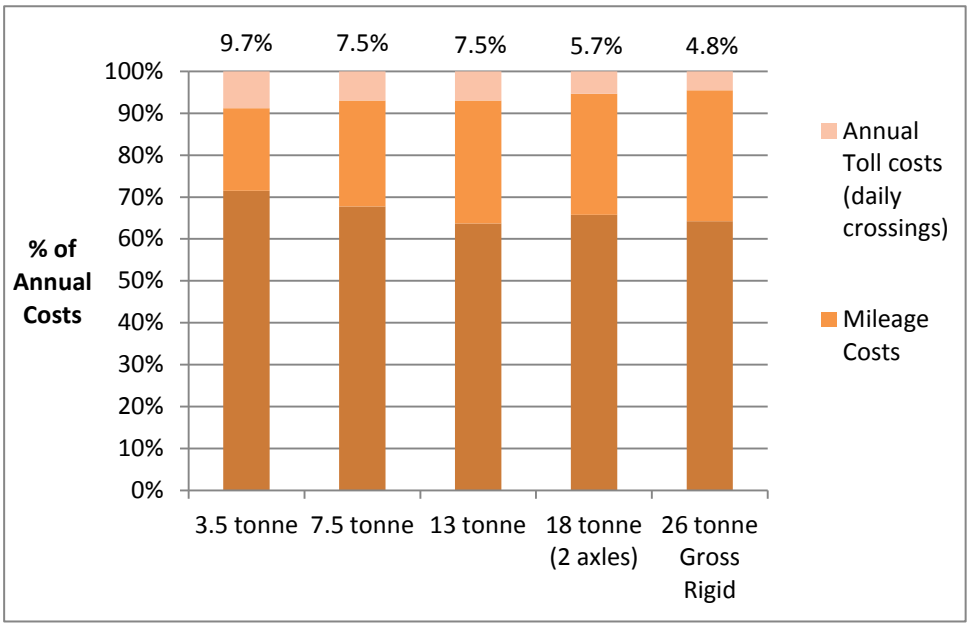
As noted, reported toll costs for an individual firm can be up to £200,000 per year. As an illustration, annual toll payments of £200,000 (if assumed to be limited to heavy vehicles) approximates to nearly 12,000 westbound crossings a year or around 32 crossings per day (based on a 365 day year). Clearly, this level of activity necessitates an operation with many vehicles. Although some transport businesses are clearly more seriously affected than others, it should be considered that toll costs are likely to be closely related to overall turnover. It is important therefore to consider the importance of toll costs set against other operating costs.

Figure 6.7 illustrates the possible composition of the annual costs of operating a heavy vehicle assuming that the vehicle uses the crossings on a daily basis[29].

[28] Freight Transport Association consultation.
[29] Source data on vehicle operating costs taken from the Road Haulage Association (RHA)

Typical operating costs have been calculated for a range of vehicle types based on 45,000 miles per annum. Wages, overheads and mileage costs (including fuel) account for a far greater proportion of total cost. However, for a 3.5 tonne vehicle, the tolls could be in the order of 10% of total costs based on a daily frequency of crossings. This is a significant level given the narrow profit margins which characterise the sector. There is a significant difference in the proportion of cost accounted for by the tolls between the smallest and largest vehicles. The implication is that the tolls will have a greater proportional impact on businesses operating smaller sized vehicles due to the levels of capital investment required for larger vehicles.

Figure 6.7 - Composition of annual freight vehicle operating costs, daily crossings[30]

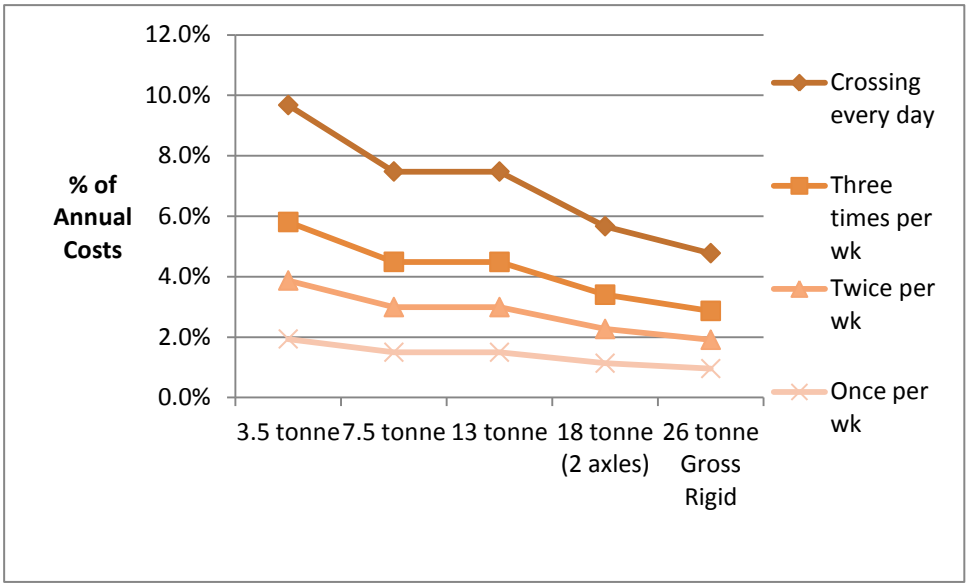


Source: Arup analysis / Road Haulage Association

The above analysis is based on a daily frequency of freight vehicle crossings. In reality, the frequency of crossings will vary across logistics firms, depending on the markets they serve and their intensity of asset utilisation. As the following figure shows, the impact of the tolls as a proportion of total operating costs is quickly diminished if lower frequencies are assumed. The above analysis could therefore be considered as representing the *'worst case scenario'* in terms of level of impact of toll costs.

[30] Based on a daily frequency of crossings, 240 per annum

Figure 6.8: Composition of annual freight vehicle operating costs, by crossing frequency



Source: Arup analysis / Road Haulage Association

Impacts on Market Size

Around one quarter of firms view their business as being at a disadvantage compared to competitors as a consequence of tolls. In depth interviews with independent hauliers revealed that most businesses, when determining their price or tendering for work, will carefully calculate the costs associated with a freight movement and price their job accordingly. This being a product of a highly competitive market for transport. The calculation of costs will typically include toll costs alongside wage costs and rates of fuel consumption.

There was a mixed response when asked whether toll costs are passed on to the customer. Some business reported that the tolls *'go straight on the bottom line',* although others reported that they will include toll costs (either explicitly or implicitly) in their price in order to recoup costs. In either case it is reasonable to assume that the tolls may influence whether a haulier chooses to try to compete in a certain markets.

In the context of the Severn Crossing, the logistics market for firms in South Wales can be broken down into three distinct components:

(i) Welsh pick up and drop off;

(ii) English pick up and drop off; and

(iii)English pick up and Welsh drop off (or vice versa).

Although hauliers also move goods further afield (to other parts of the UK and European Union) it is considered that the cost of very long distance trips is such that the toll would be a diminishingly small element of total costs.

The tolls effectively act as a barrier to entry for Welsh hauliers seeking to compete in the 'English pick up/drop off market' (ii) given that operators based on England will not be subject to the toll. Equally, however, the tolls act as a barrier to entry for English hauliers in accessing the Welsh pick up and drop off market

(ii). With regard to the third component (iii) where one leg of the journey is in South Wales and another is in England, both hauliers based in England or South Wales would be subject to the toll and therefore the competitive effect is neutral.

There is some evidence that tolls affect investment decisions. One hauliers interviewed with multiple locations reported that they have located more vehicles in depots in England rather than South Wales in order that jobs involving an English pick up and drop off can be more frequently served without paying the toll.

Toll costs have been shown to be significant for heavy goods vehicles travelling relatively short distances between England and South Wales. Section 4 set out estimates which suggested that for a heavy vehicle travelling between Newport and Bristol, toll costs could amount to nearly 30% of journey costs. Nonetheless, the greater part of the costs related to wage costs, fuel and vehicle operating costs. Therefore, Welsh hauliers seeking to compete in the English pick up/drop off market (as well as English hauliers competing in Wales) will have to overcome these costs even before toll costs are considered. Given the fuel and wage cost of travelling between South Wales and Bristol area, these businesses are already at a competitive disadvantage because of distance factors irrespective of tolls. Therefore, whilst tolls impose a significant direct cost on hauliers which is compounded by already low profit margins, the effect on the geographical market within which Welsh hauliers compete is likely to be relatively small.

6.4 Impacts on Business Investment and Location Decisions

For some firms for which toll costs are significant it is suggested in the surveys that tolls will effectively increase the cost of doing business in South Wales, thereby making South Wales a less attractive location for investment. Evidence from the business survey suggests that the quality of existing transport links (quality of access to motorways, local road network, public transport, parking) are seen as a key factor in the advantage of firms' current location.

When asked about the main disadvantages of their location, transport factors were also frequently identified by Welsh firms. The Severn tolls specifically were noted by one firm to be a disadvantage without being prompted. However, investment decisions are made taking into account a broad range of factors including availability of suitable premises, costs, access to markets and labour markets. For the majority of businesses, the cost of other business inputs, such as premises and staff, will constitute a much greater proportion of total costs than toll costs. Furthermore, it is probable that South Wales, in comparison to the South West, is considered to be a lower cost location in regard to wages and property costs, offsetting the impact of the tolls. Logically, for the toll to be a major factor in a decision as to whether to invest in South Wales, transport costs will need to be a very high proportion of operating costs and the Severn Crossings would need to be of primary importance for the transport of goods. For service sector firms and higher value manufacturing activities, toll costs are likely to be of limited significance.

A key difficulty in establishing the influence of the tolls on inward investment is identifying businesses that may have considered South Wales as a location but

decided on an alternative. As with previous reports into the tolls[31], whilst it was established that some businesses pay regard to the tolls when considering locations in South Wales, no instance could be identified where toll costs were pivotal in a decision not to locate in South Wales. The analysis does suggest, however, that for the tolls to be pivotal in an investment decision, it is highly likely that the investment in question will relate to a transport and distribution function.

There are two exceptions to this. Firstly, the influence of the tolls on the labour market is such that the tolls could be considered to artificially reduce the size of the labour market which would make recruitment of workers with relevant skills more difficult or costly, thus reducing the attractiveness of South Wales as a location for service and manufacturing sectors. Labour market issues are explored further in Section 7. Secondly, if tolling is considered to negatively affect *perceptions* of South Wales as a place to do business then the tolls might have effects beyond the cost factors described above. This point is further described below.

Impacts on Location Patterns of the Transport Sector

It follows from the above, that the tolls are more likely to be a pivotal factor in investment decisions for transport and logistics operations. In particular, a key consideration is whether the tolls act as a barrier to the establishment of Regional Distribution Centres (RDCs) in South Wales.

As with the competitiveness debate outlined above, the market area being served by the RDC is a crucial factor. Firstly, for an RDC serving South Wales *only*, the tolls would logically serve to encourage an RDC to locate in Wales. However, it should be noted that in the majority of cases the ultimate origin of the goods being moved will be east of the Severn. Therefore, for an RDC in Wales, incoming vehicle movements would have to pay the toll and therefore the RDC operation may be subject to the toll either directly or indirectly. Secondly, for a distribution centre serving the South West only, whilst the toll would impose an additional cost on a location in Wales, it is unlikely (given the physical distance and the relative importance of fuel and wage costs) that South Wales would be an ideal location, irrespective of tolls. In conclusion, the tolls are more likely to be pivotal in a decision whether to locate an RDC in England or Wales if the RDC is serving both markets.

The trend in recent decades in the logistics sector has been towards consolidation within large regional distribution centres. It is notable that the M5 corridor has benefited from this trend and has become an important location for such RDCs. It is notable that the transport sector in South Wales tends to be skewed towards smaller businesses rather than large distribution centres that are more common in the South West of England. A key question therefore, is whether South Wales has missed out on such investments because of the toll.

The distribution arm of a major retailer was interviewed to inform the study. This confirmed that, for large operations, a cost-benefit assessment of shortlisted locations is undertaken, taking into account transport costs based on detailed calculation of the mileage that company's vehicles would be required to travel to and from and site. The operator confirmed that toll charges are factored in to their

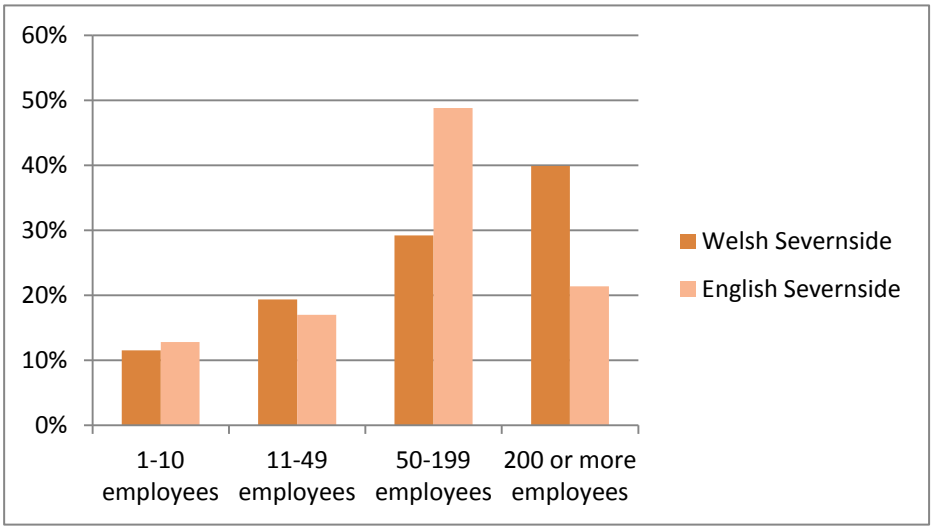
[31] Welsh Affairs Committee Report on the Severn Tolls

investment decisions. In this context it is feasible that a decision whether or not to locate in South Wales could be influenced by the toll.

As noted above, locating in South Wales would mean that vehicles would have to incur the fuel and wage costs of travelling over the bridge even if the tolls were not in place. Moreover, given the relative size of the two economies it is highly likely that, as in the case of the supermarket operator, a greater proportion of the market will be located in the South West of England. Therefore, in most cases, with regard to the location of a RDC, it is possible that the M5 corridor may still be seen as a superior location due to travel times. It should also be considered that levels of congestion and journey time reliability are also significant factors that some operators, particularly those involved in 'just-in time' operations will consider when investing. Therefore, although the effect is small, the impact of the tolls on alleviating congestion is also relevant to this debate.

In conclusion, although a specific example has not been identified, there is evidence that some businesses are factoring in toll costs into location decisions. Therefore it is conceivable that the cost of the toll could dissuade an investor from locating in South East Wales. However, the toll will only be pivotal in an investment decision in a rather unique set of circumstances and is likely to be limited to highly transport dependent sectors and only to business parks and employment land in close proximity to the Severn Crossings.

Figure 6.9 - Proportion of Employment by Size of Unit - Freight Transport by Road Sector



Source: Nomis (ONS)

6.5 The Role of Perceptions

Much of the analysis above focuses on the effects of the Severn Crossing tolls on businesses and their investment decisions based on logical inferences drawn from an analysis of the price of the toll compared with other cost factors. A theme of the interviews undertaken with businesses and business groups was that the importance of the toll extends beyond cost factors and relates to how the toll effects the way people perceive South Wales as a place to do business. Anecdotally, the perception of South Wales as a 'distant' location (for example by

those in the South East of England) is disproportionate to the actual physical distance or travel time.

Some respondents felt that the tolls reinforced a 'psychological barrier to doing business in South Wales'. This barrier, it is argued, very often applies as much to English businesses considering investing in South Wales as to Welsh businesses considering competing in markets in England. Furthermore, the principle of paying tolls can be highly unpopular or hostile to business. Therefore the toll may negatively affect people's views of South Wales as a place to do business.

Although potentially important, perceptions and their impact are difficult to measure. The above arguments are therefore difficult to test. Furthermore, whilst the tolls may re-enforce perceptions of South Wales as a distant location it is difficult to separate the effect of the tolls themselves from the psychological effect of the estuary itself or other underlying cultural factors.

6.6 Impacts on Tourism, Retail and Leisure Sectors

The discussion of the impact of the tolls on businesses has so far not considered the effects on the tourism, retail and leisure sectors. Although some of the above issues in relation to direct and indirect toll costs could apply to this sector, the key questions relate to the way consumers respond to the toll and the effect this has on patterns of retail and leisure expenditure.

The traffic analysis would suggest that non-work trips, including leisure trips, are relatively sensitive to tolls. The tolls act as a deterrent to travelling between parts of England and Wales. All things being equal, reducing the toll would be expected to result in more retail and leisure trips over the Severn Crossings. Whist this is the case, the traffic analysis simplifies a complex set of choices and tradeoffs.

Firstly, it should be noted that the degree to which the toll impacts upon tourism, retail and leisure travel would be expected to depend on the proportion of the whole cost of the trip that the toll makes up. The cost of the toll needs to be balanced against fuel costs, travel time, parking costs, entry fees etc. For longer distance trips and higher value trips, such as overnight stays, it is likely that toll costs are a diminishing proportion of total trip costs and of secondary importance in the decision of these consumers. Therefore, it is likely to be largely day trips and retail movements which would be more affected. In particular, removing the tolls could impact positively on day trip destinations such as the Monmouthshire area and retail destinations, most notably Cardiff City Centre.

Secondly, it should be considered that removing the toll would be expected to stimulate higher demand for leisure travel over the Severn in both directions. Therefore, as with other sectors, the effect of the toll may be to insulate the local retail and tourism sector from competition. The net effect of removing the toll is ambiguous. South Wales has a strong tourism sector and might therefore be expected to benefit from greater movement. Furthermore, while in the past South Wales has experienced 'leakage' of retail expenditure to competing centres, it is possible that recent developments, particularly in Cardiff, may have resulted in South Wales becoming a net attractor of retail trips. To illustrate this, the Venue Score 2011-12 report by Javelin Group, which ranks UK cities and shopping centres, places Cardiff 10th and Bristol 11th amongst town and city centres and, in

terms of shopping centres, the St. David's Centre in Cardiff ranks 13th compared to The Mall at Cribbs Causeway in Bristol which is ranked at 17th.

Visitor Perceptions

The view from the tourism sector is that the Severn Crossing tolls could negatively affect perceptions of a visit to Wales and that this could re-enforce the perceived distance of Wales as a leisure or holiday destination. It was also suggested that negative perceptions were further reinforced by the experience of visitors having to queue at the toll booths. Given that very long queues have been experienced in the run up to major events or on Friday evenings, a major concern is that visitors will be deterred from making return visits as result.

Given that the debate centres on the behaviour of consumers rather than businesses, a further survey was undertaken of 614 households from across the South West of England. The purpose of the survey was to assess consumer awareness of the Severn Crossings Toll and to understand how the toll might influence the propensity of people to visit Wales[32]. Limiting the survey to the South West of England ensured that the survey captures the views of people who are likely to be considering a visit to Wales. Based on the logic set out above (that the importance of toll costs will diminish with distance) it would be reasonable to assume that if consumers are influenced by the toll then they will be found in the South West of England. Equally, because the survey covers all counties within the South West it is broad enough to allow comparison of responses by distance from the tolls.

This survey is intended to provide an indication of the significance of the tolls. However, given the difficulties implicit in behavioural surveys of this nature, the results should be interpreted with caution. In particular, it is difficult to draw firm conclusions of magnitudes given the sample size of respondents.

The survey found that 35% of respondents reported having visited Wales for recreation reasons in the previous 12 months. As can be seen in the Table 6.4 below, the nature of recreation trips to Wales were spread across shopping, leisure, holiday and visiting friends/relatives. Those who did not make any trips to Wales by car in the previous 12 months were asked for the main reason not to make a trip to Wales. Only 3% responded that the Severn Toll was the main reason not to make a trip.

Table 6.4 – Number of recreation trips made in Wales by car in the last 12 months

Number of trips	Shopping	Leisure (day trip)	Leisure (1 or more nights)	Holiday	Visiting friends/ relatives (day trip)	Visiting friends/ relatives (1 or more nights)
0	90%	86%	86%	89%	92%	89%
1	5%	8%	10%	8%	4%	5%
2	2%	2%	3%	1%	2%	2%
3+	3%	5%	2%	2%	3%	3%

Source – Arup analysis

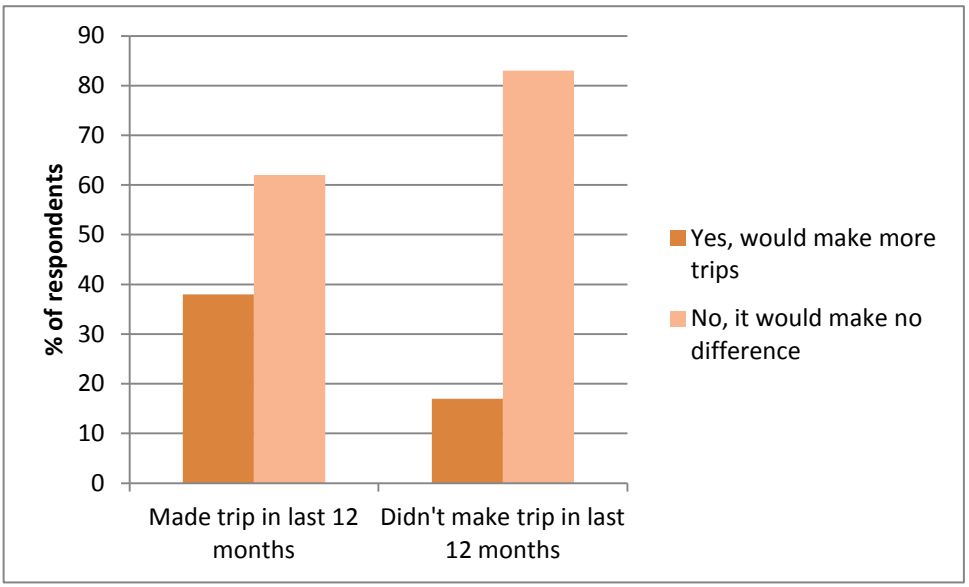
[32] The results of this survey can be found in full in Appendix D.

The survey found that 42% intend to visit Wales for a recreational visit in the next 12 months. When asked if they would expect to make more trips to Wales by car if the Severn tolls were removed, 22% said they would expect to make more trips to Wales in the next twelve months. Whilst this is a significant proportion, it should be noted again that due to likely optimism bias, thus one should focus on the general trend rather than exact percentage changes.

When these responses are analysed in more detail it is notable that respondents who are residents closer to the crossings had a higher proportion saying they intend to make more trips to Wales. For example, 31% of the respondents who expected to make more trips if the toll were removed were from Bristol who made up 16% of the sample as a whole. This supports the theory that it is shorter trips, where the toll make up a more significant proportion of total trip costs, that are most affected by the tolls.

Also, when the responses are cross tabulated against whether respondents made trips by car to Wales in the last 12 months it can be seen that 38% of those who made trips in the previous year would expect to make more trips in the future should tolls be removed whereas of those who hadn't made a trip in the previous 12 months only 17% would expect to make more trips should the tolls be removed, so that those who already make leisure trips to Wales would be more likely to make more trips rather those who don't already make trips.

Figure 6.10 - Propensity to Visit Wales if the Severn Crossing Tolls were Removed



Source – Arup analysis

7 Labour Market Impacts

7.1 Introduction

Based on the current toll cost of £5.70 per vehicle, toll costs for a commuter crossing the Severn Bridges each working day would amount to around £1,400 over a year. This level of expenditure is significant if compared with average household expenditure on the operation of personal transport (see Family Spending Survey 2007 where average yearly spend on personal transport in England and Wales was just under £1,500 per annum). Therefore tolls are a potentially significant factor in affecting individual's job search area, although long distance commuting costs are already high.

The traffic analysis suggested that removing the tolls would result in an increase in commuting across the Severn Crossings of 11% (excluding reassignment effects) if the labour market assumptions within the traffic modelling are retained. The aim of this section is to outline the evidence for the ways in which labour market conditions within the broader study area are likely to either underpin or attenuate such a growth in levels of commuting.

7.2 Impact Assessment

Local labour markets are complex. Mobility, recruitment and job search geographies vary by sector and by occupation. Individuals typically make their commuting decisions based on three factors:

- The balance of job opportunities and differentials between the home location and the potential work location;
- Differences in the costs of living and the quality of place/living; and finally
- The costs of mobility both in direct costs but also in terms of time.

This section considers the effect of the toll in the context of these factors.

Toll Costs, Wages and Commuting Demand

There is a clear differential in potential earnings (up to £114 difference in median earnings between local authority areas) and in economic activity (10% difference in employment rates) across the Severn. Over the period 2004-2011 there has been a consistent 10% difference in the employment rates of the sub-regions on the English and Welsh sides of the Severn suggesting that there is a structural component to unemployment that results in this consistent 10% in good economic times (2004-08) and bad (2008-10). Table 7.1 shows the difference between the median gross weekly earnings in the local authority areas of the study area.

This indicates that there is a clear tendency for in-commuters to be attracted across from South East Wales (while recognising that these aggregate figures do not compare wage levels in comparable jobs). Within the table, the figures in red indicate that there is a negative aggregate earnings differential between any two locations (that might dampen commuting) whereas the figures in black indicate a positive aggregate differential (that might induce commuting). They indicate that on average the type of employment located in South Gloucestershire in 2010 paid more than the type of employment offered in South East Wales. Currently, these potential aggregate earnings differentials can be understood as being offset against

the costs of commuting that include the toll charge albeit that these earning differentials are not based on potential earning differentials for individuals (that would take occupation and qualifications of individual workers into account).

Table 7.1 - Median gross weekly earnings differentials between local authority areas, 2010

	location for 'wage differential'									
	Bath and North East Somerset	Bristol, City of	North Somerset	South Gloucestershire	Stroud	Caerphilly	Cardiff	Monmouthshire	Newport	Torfaen
Bath and North East Somerset	-	£13.10	£22.40	£43.30	£1.60	-£34.00	£1.00	-£70.50	-£10.90	-£45.60
Bristol, City of	-£13.10	-	£9.30	£30.20	-£11.50	-£47.10	-£12.10	-£83.60	-£24.00	-£58.70
North Somerset	£22.40	£9.30	-	£20.90	-£20.80	-£56.40	-£21.40	-£92.90	-£33.30	-£68.00
South Gloucestershire	-£43.30	-£30.20	-£20.90	-	-£41.70	-£77.30	-£42.30	-£113.80	-£54.20	-£88.90
Stroud	-£1.60	£11.50	£20.80	£41.70	-	-£35.60	-£0.60	-£72.10	-£12.50	-£47.20
Caerphilly	£34.00	£47.10	£56.40	£77.30	£35.60	-	£35.00	-£36.50	£23.10	-£11.60
Cardiff	-£1.00	£12.10	£21.40	£42.30	£0.60	-£35.00	-	-£71.50	-£11.90	-£46.60
Monmouthshire	£70.50	£83.60	£92.90	£113.8	£72.10	£36.50	£71.50	-	£59.60	£24.90
Newport	£10.90	£24.00	£33.30	£54.20	£12.50	-£23.10	£11.90	-£59.60	-	-£34.70
Torfaen	£45.60	£58.70	£68.00	£88.90	£47.20	£11.60	£46.60	-£24.90	£34.70	-

Source- Annual Survey of Hours and Earnings, ONS Crown Copyright Reserved [from Nomis]

If the toll is removed, economic theory reflected in the traffic model predicts that the effect of any earnings differential is likely to be reinforced for residents of South East Wales leading to increased propensities to commute (that in turn may be reinforced by relative housing market variables – see Cameron and Muelbauer 1998).

The traffic modelling considers the degree to which different scenarios of toll regime might modify the costs of mobility that induce or reduce the propensity of workers to commute using the Severn Crossings. As noted, the modelling suggests rises of up to 11% after 2018 if tolls are removed completely and a 5% reduction in the case of tolls being increased by 50%. Although reassignment effects are expected, the main driver of this change is increased demand for commuter travel, either because of people switching mode of transport or because commuters are now willing to travel longer distances.

The aggregate wage differential data suggest that the bulk of this commuting growth would be from Wales to England in the AM peak. This assumes no significant change in the geography of employment in the study area or significant changes to the practice of work (being principally located in a single fixed place of employment).

Given the occupational profile of commuters and the fact that higher paid workers are typically more mobile than lower paid workers, it is likely that additional

commuters will also be above average in terms of pay and skill levels. The inference from this is that the additional commuting is likely to primarily represent changing employment search areas or changing distribution of employment rather than any increase in participation rates.

Housing and Land Use Impacts

The modelling has not considered the impacts of the interplay between the costs of living (such as housing) and the quality of place as a driver of increased commuting in these scenarios. It is feasible that changes in the cost of commuting might have the impact of changing where workers choose to live in the study area. Thus, reductions in travel costs might result in workers choosing to live further away from their place of work in order to benefit from a mix of cheaper housing (at least initially) or the capacity to buy more space (and to benefit from amenity value) (Kim et al 2005). Cameron and Muelbauer 1998 based on inter-regional commuting and migration data in Great Britain through the 80s and 90s suggest that relative housing market conditions have "quite significant impacts on commuting patterns". For movements between contiguous regions labour market factors will have a weaker effect where commuting costs are relatively low (or lowered) whereas housing market factors will be more important on decisions to migrate.

Studies of labour market adjustment in both Australia (Debelle and Vickery 1999) and the United States (Shields and Swenson 2000) suggest that labour market adjustment through migration is generally complete within 5-7 years. Whereas researchers such as Hughes and McCormick (1991) suggest that there is a certain reticence for British owner-occupiers to move house to take advantage of employment opportunities due to the transaction costs of moving home, it is likely that migration-related labour market adjustments would probably be witnessed over a similar period in the UK. Thus, one might expect to see any migratory pressure induced by changes in the toll regime by 2018 (the first time period for the traffic modelling).

Rural parts of Monmouthshire may offer interesting opportunities for households seeking rural locations at more affordable prices that in the northern part of the Avon area and Gloucestershire. Based on reviewing data from the commercial property website Zoopla for the four local authorities in the study area that might be considered to offer rural amenity the data suggests that housing in Monmouthshire is competitively priced in comparison with South Gloucestershire. These valuations suggests that the housing stock in Monmouthshire is valued at 75% of the value of properties in South Gloucestershire by square foot across a range of dwelling types and that property is valued at around 90% of those in Stroud. Values per square foot in Monmouthshire are around the same as for North Somerset. It is clear from the housing needs assessment carried out on behalf of the local authorities of Monmouthshire, Newport and Torfaen that these planning authorities are projecting migrant-led housing pressure in particular within the Chepstow and Caldicot housing market area to the south of Monmouthshire (Opinion Research Services 2005). It is likely that reducing the toll regime would increase the housing market pressure to the South of the county driven by commuters to Bristol and South Gloucestershire.

A second series of changes that might arise within the study area relate to changes in the geography of jobs. This is predicated on local planning authorities making

land available for development in appropriate locations but does raise questions about the likely impact of these new jobs on commuting patterns. Shields and Swenson (2000) explored the degree to which new jobs created through economic development policy in Pennsylvania were captured by commuters to the locality. They found that the degree to which new jobs were captured by in-commuters depended upon the type of industry. Whereas there does not appear to be an equivalent study in the UK, the UK evidence clearly suggests that any new jobs generated in an area are more likely to be taken by those already in employment with there being a subsequent 'trickle down' effect for those who are workless (see Gordon 2000 for work based on the London labour market). Thus, if the new employment is well paid equivalent to wage levels on the English side of the crossing, there may be some increase in commuting from England (if commuting costs have been lowered). However it is also likely to generate some turn-over within local labour markets across South East Wales.

Other Limitations

There are a number of challenges in predicting the future of commuting traffic. Clearly, there is the issue of fuel costs where fuel (either unleaded petrol or diesel) is currently at levels 50% higher than was the case in the summer of 2006. Equally through the 2000s there has been the emergence of forms of flexible working whereby some workers can now work at home (at least for part of the week) and might work at a number of different 'bases' outside of the home. However, this is a pattern that is also difficult to predict. Data suggests it relates more to the management ethic of the individual business than to specific occupations or to specific sectors (see Ruiz and Walling 2005). Hotopp (2002) using data from the Labour Force Survey for the UK identifies a growth of between 60% and 70% in the period 1997-2001 with distinct clustering of teleworking amongst the self-employed (62% of teleworkers), within the managerial and professional occupations (around 75% of teleworkers) and within the real estate, renting and business services sectors (accounting for 25% of all teleworkers). Given that these occupations and sectors are prominent in the 2001 commuting flows across the Severn Crossings, it is plausible to suggest that some of the commuting growth projected for the Crossing may be mediated by changes to more teleworking for professional and business service workers from Monmouthshire (currently the single largest origin of commuting traffic across the crossing). However, such changes may result in some increases in traffic relating to business operation (rather than commuting).

Implications

Overall it is important to assess the institutional facilitators and barriers to the predicted change in commuting traffic flows across the Severn Crossings. Whereas it is likely that reducing or removing the toll from the crossings will induce higher levels of commuting, these higher levels may only be realised if there are the appropriate spatial planning framework in place. Most concretely, the spatial planning framework would need to facilitate the assembly of development land if the aim is to change the geography of jobs in the study area.

Given changes in the toll regime may induce change in both the potential geography of employment and of accessibility to employment (through increasing affordability of commuting via the Crossings), planning authorities will also need to consider the impact of changes in the toll regime on local housing markets. One might expect a mix of lower house prices and reduced commuting costs (if

tolls are reduced) to make Monmouthshire more attractive to workers with jobs in the Greater Bristol area. If this proves to be the case, it would be reasonable to expect house prices to reflect this increase in demand. Planning authorities would then be faced with the issue of supporting on-going affordability through increasing the supply of housing for private owner-occupation in response to the increased demand (through new development on top of current provision) or letting prices rise in ways that are likely to disadvantage poorer households who might be priced out of home ownership (through not increasing new development) in the county.

8 Effects on Productivity

8.1 Introduction

This Section considers the implications of the tolls on the performance of the economy through application of economic modelling techniques. Unfortunately, as we have seen above, there is little evidence available of the impact of tolls on economic activity. As a result, the approach taken is to estimate the extent to which differences in economic performance (in this case measured as productivity) can be explained by spatial factors that are in turn influenced by transport costs (including toll charges). Our hypothesis is that reducing tolls reduces transport costs and has the same effect on economic performance as investment in transport infrastructure that reduces journey times. We further hypothesise that the superior economic performance associated with locations that are close to centres of high economic activity will also be enjoyed by locations that benefit from reduced travel costs to such centres.

First, it is necessary to consider the literature relating economic performance and transport infrastructure investment. Secondly, we explore the mechanisms whereby economic impacts might be transmitted and consider the extent to which modelling can capture these. Then, we describe the methodology for estimating the impact of various toll scenarios. Finally, we discuss the results and application of our estimations.

The following section presents the results from exploratory modelling techniques. As such the analysis is intended to help to establish statistical relationships between transport and accessibility and economic performance. The results are intended to illustrate the nature of these relationships and given that there is significant uncertainty in the results provided, the precise estimates provided are also illustrative.

8.2 Previous studies of the impact of transport infrastructure

The impact of tolls is seen primarily as influencing travel cost and thus the quality of access between centres of economic activity. Previous studies into the link between transport and economic performance have defined specific measures of accessibility and associated spatial concepts such as peripherality and agglomeration (concentration of economic activity). Many of these measures combine a spatial measure of travel cost, whether in time, distance or money terms, to various centres of economic activity with a measure of the importance of those centres in economic terms. For example, a measure of the accessibility of an area might be based on the travel time from the centre of that area to a range of urban centres weighted by the working age population of each centre. This is sometimes referred to as accessibility to economic mass.

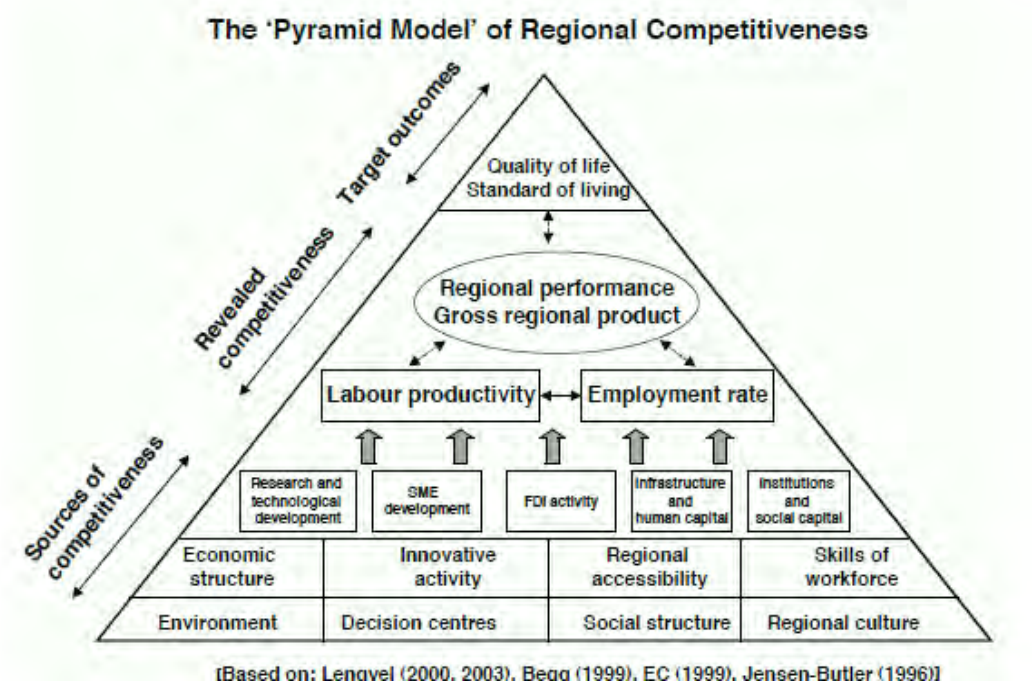
Typically, studies demonstrate that improved accessibility is associated with improved economic performance in general. There is no attempt to separate out the contribution of labour market effects, supply chain implications, impact on the access to markets or business location decisions. The approach is to suggest that there is a significant relationship between accessibility and economic performance

which can be estimated and this allows the impact of a range of transport infrastructure changes on economic performance to be forecast.

The studies discussed below provide a theoretical framework for understanding the impact of changes in accessibility on economic performance.

Gardiner et al (2004) suggests that increased accessibility enhances regional competitiveness resulting in enhanced economic performance. This view is summarised in Figure 8.1. Gardiner argues that regional accessibility is a source of competitiveness (alongside other factors such as economic structure, innovation and skills, which are the foundations of "revealed competitiveness" which leads to improved performance and is reflected enhanced labour productivity and a higher employment rate.

Figure 8.1 – Accessibility and Regional



Source: Gardiner et al (2004)

Considerable attention has been given in both journal papers and commissioned studies to the economic benefits of agglomeration and proximity to economic mass. These benefits include a large supply of business inputs and a large market for output. Both internal and external scale economies can be achieved and collaborative working facilitated, particularly in terms of innovation. A number of studies have shown that these benefits are reflected in increased productivity. Innovation is a major factor linking agglomeration to improved economic and business performance. This includes concepts of regional innovation systems, innovative milieu, and innovative clusters[33].

The agglomeration and regional innovation literature also contributes to an understanding of business location decisions. In one way or another, most work on business location decisions gives prime importance to accessibility. What changes as the literature develops over the last 100 years is the object of access. In the early work of Losch and Christaller it was access to sources of supply and

[33] For a survey of this literature see Rosenthal and Strange (2004).

markets. More recent work has emphasized the importance of access to partners in accumulating knowledge for innovation. However, studies of actual business location decisions have revealed the importance of lifestyle factors in new locations to maintain the loyalty of key senior staff.

Market size is clearly an aspect of agglomeration but has also been investigated directly to determine impact on business performance. Rice and Venables (2004) looked at the impact on productivity of economic mass, measured as the size of the working-age population within a given drive-time of each NUTS 3 area across Great Britain. They find a significant effect of proximity to economic mass on productivity. This is greatest for mass within 40 minutes drive time and tapers off quite steeply to zero beyond around 80 miles. Just over a third (34%) of the predicted spatial variation in UK productivity is attributable to variance in economic mass, compared to 46% that is due to variance in levels of qualification and other region-specific factors.

Over the last 10 years, HM Treasury has emphasised productivity as the key to enhanced competitiveness and economic performance and has set regional agencies with the task of reducing differentials compared with the best performing regions. This has resulted in a range of studies with the objective of investigating the determinants of productivity so as to inform policy interventions. Much of this work was based on investigation of productivity drivers at the firm level. Members of the UWE team carried out studies of this type for the South West Regional Development Agency and the Welsh Government (see Boddy et al (2005, 2006 & 2007). In addition to accessibility, these studies have shown the significance of scale, skills, investment, ownership and exposure to export markets as major factors driving productivity.

The firm level approach has also been used to investigate the impact of transport infrastructure improvements on agglomeration benefits resulting from enhanced accessibility. Graham, D, (2008) investigated the impact of agglomeration on productivity. The productivity variable was based on 1995 to 2002 FAME data and agglomeration on distance/ generalised cost of travel to all other destinations at ward level. The results of this work have subsequently been incorporated into the Department for Transport's transport appraisal guidance as a means of estimating the wider economic impacts of transport improvements. Application of these estimates to transport improvements across the UK has led to estimates of agglomeration benefits of between 10% and 30% of direct transport benefits (or cost savings)[34]. The magnitude of such estimates is strongly influenced by the context within which the transport improvements take place, including the presence of business sectors which are sensitive to agglomeration.

Later work by Graham et al (2009) indicates agglomeration impacts on wage levels are smaller than previously thought and more limited in geographical range. This might be taken to indicate that agglomeration impacts on productivity are also likely to be more modest and more subject to decay over distance. However, this may not be the case for a number of reasons: firstly Gross Value Added (GVA) per Full Time Equivalent (FTE) employee, the productivity measure used here, reflects profits as well as wages and thus may not be strongly correlated with

[34] The Eddington Transport Study

wages alone[35]; secondly, labour market effects can impact on wages without effecting the productivity of a firm, at least in the short term; finally, individual businesses can prosper through product market factors and successful innovative strategies, increasing profits while wages remain determined by local factors and are unaffected.

The attenuation of impact of agglomeration on wages with distance does not necessarily suggest that the impact of the Severn tolls on productivity will follow similar sharp attenuation with distance from the crossing. It may be that the impact of toll changes on travel to work patterns are sharply attenuated, although Graham et al do not provide any direct evidence for this. However some of the impacts of infrastructure improvements on productivity have little to do with travel to work but are based on freight transport costs effecting both physical inputs and outputs, business travel and recreational trips. Nevertheless, although the findings of Graham et al may not be fully applicable to the methodology used here, it does signal the need to excercise some caution in drawing conclusions from our results.

In conclusion, the literature reviewed above gives substantial support for the investigation of toll impact through the relationship between accessibility and productivity. This literature, in particular the work by Graham et al has contributed to the assessment of economic benefits in the Department for Transport's New Approach to Transport Appraisal (NATA), a cost-benefit analysis framework for trasport infrastructure appraisal. This framework is not precisely followed here for reasons explained in section 8.4 below. However comparisons are made with the results of studies using this methodology.

8.3 Mechanisms for transmitting the impact of tolls

The actual toll levied and the interruption and delay at the toll booths represent an increased travel cost. This will increase business transport costs, increase the cost of commuting and increase the cost of shopping and leisure activities that involve crossing the Severn. This will influence the spatial distribution of economic activity on both sides of the crossing, impacting on business performance, location decisions and logistic strategies, travel to work patterns, retail catchments and the destination of leisure and tourism expenditures. To track these impacts directly would necessitate a massive amount of survey work. However, it is possible to generalise the impact of tolls in terms of the consequences for travel cost and thus accessibility.

The economic impact of tolls can be divided into *direct effects* represented by additional generalised costs of travel to crossing users and *indirect effects* resulting from changes in economic efficiency and structure in response to the direct effects. These indirect effects are also referred to as *wider benefits* in much of the transport infrastructure appraisal literature. As noted above, considerable emphasis is given in this literature to agglomeration as an important mechanism for the transmission of these indirect effects. The concept of agglomeration can be traced to Alfred Marshall's *external economies of scale* which include the impacts of linkages between intermediate and final goods suppliers, labour market

[35] Empirical studies show that wages and productivity frequently diverge, especially in the short term and at various stages in the economic cycle. See, for example Sharpe et al (2008), Bottazi and Holm (2011), Dickerson and Mckintosh (2011)

interactions, and knowledge spillovers. These are alternatively described by Duranton and Puga (2004), who classify the sources of agglomeration economies as ‘sharing’, ‘matching’ and ‘learning’. As summarised by Graham et al (2010), ‘sharing’ refers to the sharing of indivisible facilities, intermediate suppliers, workers and consumers by firms, which reduces fixed costs, allows specialisation and allows firms to pool risks. ‘Matching’ benefits are usually discussed in terms of having lots of workers in close proximity to employers, which means it is easier for different types of worker and different types of employer to find each other, and more productive matches occur at a faster rate. ‘Learning’ refers to the transfer of information, knowledge and skills. The importance of proximity and the possibility of face to face contact in facilitating knowledge exchange and the transfer of skills results in the persistence of agglomeration economies in the face of ever increasing sophistication and availability of communication technologies.

Below we explore the impact of crossing tolls on the economy through their influence on generalised cost and thus accessibility. We estimate the relationship between accessibility and productivity from data on firms in England and Wales. We suggest that a change in accessibility will, in time, result in a change in productivity and thus economic performance. The use of this methodology to investigate the impact of bridge tolls makes a basic assumption in using cross sectional data to predict impacts over time. This is that the relationship between the productivity of a sample of firms and the accessibility of their locations will hold for the generality of firms in that area when changes in tolls alter effective accessibility. It can be argued that the long term impact of accessibility on productivity will reflect both the direct and indirect effects discussed above. Table 8.3a illustrates the extent to which these effects might be captured, some of which are in addition to agglomeration effects.

Table 8.1 - Economic Impact Mechanisms for bridge tolls

Impact factor	Impact link	Timescale	Extent reflected in accessibility – productivity relationship
1.Market size (indirect)	Agglomeration benefits Larger markets, wider supply chains	Long term	**Entirely** - including through higher output prices and lower input costs
2. Inward investment/business location (indirect)	Sector-specific growth Multiplier effects Agglomeration benefits	Long term	**Partly** - as productivity increases with economic activity – extent dependant on spare capacity and nature of inward investment
3. Business outward relocation (indirect)	Sector-specific decline Multiplier effects Reduced agglomeration benefits	Long term	**Partly** - as productivity decreases with reduced economic activity –extent dependent on staff retention and nature of businesses
4. Business user costs –absorbed or passed on in Business to Business transactions (direct)	Reduced value-added in specific sectors	Short term	**Entirely** – increased input costs
5. Business costs passed on to households (indirect)	Expenditure switching – some loss of local demand in certain sectors	Short term	**Partly** - as productivity decreases with reduced economic activity
6. TTW patterns (direct and indirect)	Skills availability	Medium term	**Entirely** – skills drive productivity
7. Retail catchment/leisure trips (direct and indirect)	Sector specific growth/decline Multiplier effects	Medium term	**Partly** - as productivity increases/decreases with increased/reduced economic activity
8. Household services catchment (direct and indirect)	Localised sector specific growth/decline Multiplier effects	Medium term	**Partly** - as productivity increases/decreases with increased/reduced economic activity

The impacts and coverage in Table 8.3a can be compared with the Table 8.3b below derived from the Department for Transport, Transport Appraisal Guidance, Module 2.8 (TAG 2.8). The impacts are referenced to the accessibility-productivity relationships in Table 8.3a above.

Table 8.2 – Economic Impact Mechanisms Quantified under DfT Appraisal Guidance

Appraisal Type	Appraisal Impact
Conventional Appraisal	Business user benefits (money costs, journey time, etc) (Table 8.3a, 1)
	Other user benefits (commuting, leisure) (Table 8.3a 6 & 7)
	Other impacts (safety, emissions, etc)
Wider Impacts Appraisal	Agglomeration (Table 8.3a 1 & 2)
	Output change in imperfectly competitive markets (Table 8.3a 1& 2)
	Labour supply impacts (Table 8.3a 6)
	Move to more or less productive jobs (Table 8.3a 6)

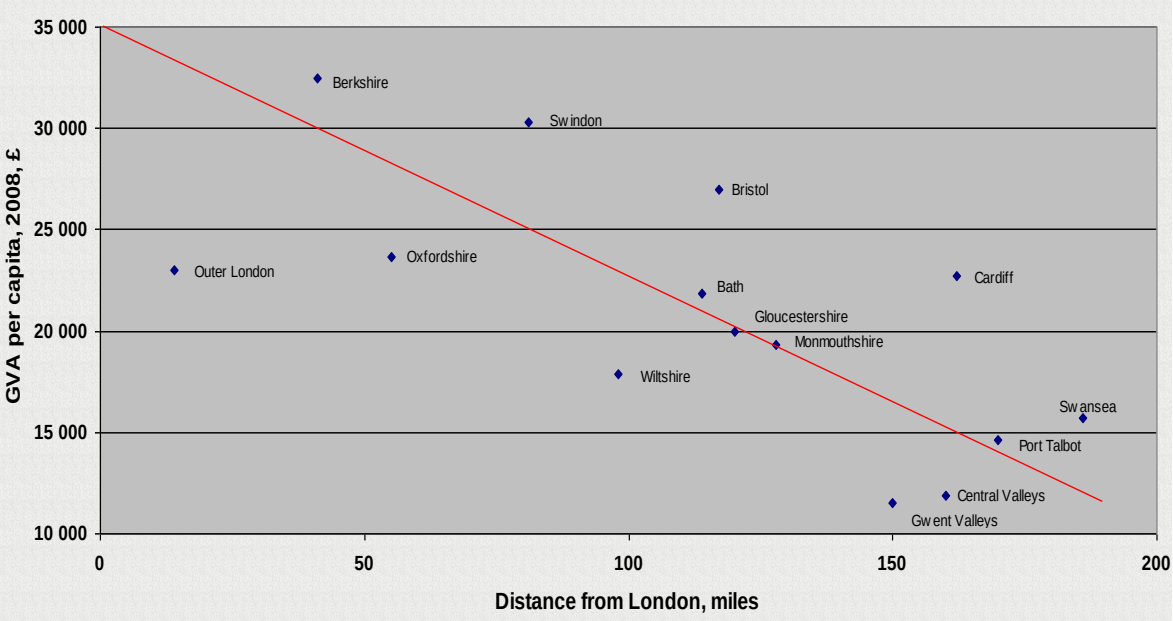
Source: Department for Transport, Transport Appraisal Guidance, Module 2.8 (TAG 2.8).

8.4 Economic impact methodology

The economic impact of bridge tolls are calculated based on a model derived from previous UWE studies which have established a relationship between proximity to economic mass and business performance (Boddy et al, 2008). That is to say that being closer to an area of strong economic activity typically has a positive impact on business performance due to factors including access to markets, linkages and labour market effects. In this model business performance is the dependent variable which is given in terms of productivity, specifically Gross Value Added (GVA) per employee.

An illustration of the strong association between productivity and proximity to economic mass can be seen from the reduction in productivity travelling west along the M4 corridor. The M4 has proved to be a powerful determinant of economic development, especially as a result of the improved access given to the largest economic mass in the UK centred on London. The impact of access to this economic mass along the M4 corridor can be demonstrated by looking at NUTS3 area productivity measured by GVA/capita from 2008 ONS data. A simple scatter plot of productivity and distance from Marble Arch to centroid of each area is shown below.

Figure 8.2 – Productivity and distance from London: NUTS 3 Areas



Source: ONS and authors' calculations.

As is the case with the aggregate productivity data discussed in section 3.2.2 above, output is allocated to the workplace while the denominator is the area's residential population. Thus this overstates productivity of commuting destinations. Nevertheless a marked reduction in productivity is evident moving west along the corridor. Every 10 miles from London productivity/capita declines by £1,250. But not only are comparisons distorted by commuting patterns –the productivity of under-bounded areas such as Bristol City are overstated, accessibility to local economic mass ignored. There is also a need to allow for other factors such as variations in economic structure. These problems can be overcome by investigating the spatial relationship using firm level data. This will allow other factors to be investigated such as scale effects and capital stock. The model which facilitates this approach is described below.

8.5 The econometric model and estimation of toll impact

It was decided to use a bespoke model rather than following the Department for Transport's NATA framework for the assessment of wider economic impacts and the productivity effects of higher agglomeration.. There are three reasons for this. Firstly, previous work undertaken for the Welsh Assembly Government[36] responded to a concern about the economic impact of the geographical peripherality of Wales in relation to the rest of the UK. A peripherality index was used in this work and it makes sense to use the same spatial variable again. Secondly, the barrier posed by the Severn crossings is an aspect of inter-regional rather than regional or local proximity to economic mass. Our peripherality index relates to all other areas of England and Wales rather than regional centres and thus is an appropriate measure. Thirdly, the NATA framework is a form of cost

[36] See Boddy et al 2008

benefit analysis which considers the economic efficiency of a transport intervention at UK level rather than a study of the particular effects of transport conditions in South Wales. Only of relevance here is the methodology for establishing agglomeration and wider benefits associated with changes in generalised costs.

The stages in estimating toll impact are as follows:

- Construct a peripherality index for all UA and NUTS 3 areas of England and Wales, Wales alone and South East Wales;
- Estimate productivity – peripherality relationship for England and Wales using latest available firm level;
- Calculate the change in peripherality of each UA and NUTS3 area in SE Wales for each toll scenario, and;
- Using the latest available or forecast aggregate area data on GVA derive change indicated for each toll scenario.

These stages are described in greater detail below

8.6 Measuring Peripherality

The peripherality measure used was based on the formula described by Keeble el al (1982).

The formula used was: $$P_i = \sum_{j=1}^{n} \frac{M_j}{D_{ij}}$$

Where *M* denotes economic mass and *D* is a measure of distance. The simplistic formulation was chosen as it minimised the potential impacts of problematic assumptions in deriving peripherality. A peripherality index was defined as in Boddy et al (2008) using a gravity-model formulation based on the generalised cost of travel between places by road and a measure of the potential of interaction between places based on economic mass in terms of either working population size (UA areas) or total GVA (NUTS 3 areas). This index was built up at unitary authority/NUTS 3 level across the whole of Wales and England. It provides a broadly-based index combining economic mass and travel cost relative to all other places in Wales and England.

In deriving peripherality, three basic vehicle types were considered[37] reflecting the Severn Crossings toll structure. Generalised costs of travel were calculated by the method described in Section 5, which combines toll costs with fuel costs and the cost of lost time (including toll delay). An overall average cost was calculated weighted by the traffic volumes of the three vehicle types.

Peripherality is similar (although inversely related) to the proximity element used in Graham (2007) and now applied to transport investments under the Department for Transport's appraisal guidance. However, the latter is built up at the ward level. Moreover, the economic mass element differs in that Graham uses employment density as opposed to aggregate working population and GVA used here. Graham's work has contributed significantly to the NATA framework.

[37] Cars, Light Goods Vehicles and Heavy Goods Vehicles

8.7 Estimations of the relationship between peripherality and productivity

A full technical discussion of the estimations and the results is given in Appendix B. In addition to the determination of the influence of peripherality on the productivity of firms in SE Wales, some further conclusions can be drawn about the economic performance of Wales in comparison to England. These are discussed in the Appendix B. The main methodological issues are summarised here and an overview of the results presented.

8.7.1 Firm level data

The project uses two firm level data sets. The first is the Annual Respondent's Database (ARD). This is a stratified sample drawn from the larger Annual Business Inquiry (ABI). The ABI is a census of large businesses, and also includes a sample of smaller ones. The ARD is from business respondents returning the questionnaires that are sent out by the Office of National Statistics (ONS). The ARD is available for the years 1973-2008. From 1997 onwards there is explicit information on firm's characteristics (e.g. Size of labour force, productivity, capital expenditure) by eight different industries: construction, catering, motor-trade, production, wholesale, other services, retail and property.

The second data series is the Capital Stock data series. The Office for National Statistics (ONS) does not ask firms what their capital stocks are; hence, it is necessary to construct capital stock series and then link these to the other confidential data sets held within the Virtual Micro data Laboratory (VML). The Micro data Analysis & User Support (MAUS) team calculates the capital stock series.

8.7.2 Data Issues

The analysis joins data sets from eight different sectors. Table 8.7a provides the number of firms by region. The striking issue here is that over the period the number of observations for Wales declines dramatically from 2006 onwards from over 4,000 to less than 1,500. In 2006 and 2007, Welsh firms in the ARD represent 3.5 per cent and 3.6 per cent of the total compared to 7.6 per cent and 7.4 per cent in 2004 and 2005 respectively. For all other regions the proportion of firms in the total sample remains fairly constant.

Table 8.3 - Sample Size by Region

	2004		2005		2006		2007	
	Sample	%	Sample	%	Sample	%	Sample	%
London	17,712	33.22	17,271	33.14	14,230	33.95	15,499	33.87
East Anglia	2,080	3.9	2,034	3.9	1,714	4.09	1,856	4.06
South-West	4,339	8.14	4,311	8.27	3,678	8.77	3,902	8.53
West Midlands	4,446	8.34	4,381	8.41	3,677	8.77	4,089	8.94
East Midlands	3,680	6.9	3,606	6.92	3,017	7.2	3,221	7.04
Yorkshire and Humberside	4,192	7.86	4,128	7.92	3,475	8.29	3,709	8.11
North-West	4,851	9.1	4,723	9.06	3,892	9.29	4,230	9.24
North	1,953	3.66	1,886	3.62	1,614	3.85	1,791	3.91
Wales	**4,041**	**7.58**	**3,840**	**7.37**	**1,475**	**3.52**	**1,666**	**3.64**
Scotland	6,017	11.29	5,943	11.4	5,145	12.27	5,792	12.66
Total	53,311	100	52,123	100	41,917	100	45,755	100

Source: ARD2

The robustness of the results are prejudiced by the small sample for Wales and especially south east Wales. This can be partly overcome by pooling years, taking the latest year's data for firms appearing across a number of years. Data after 2007 is not in any workable form at present so cannot be used in this report. Sample sizes are displayed in Tables 8.7b and 8.7c.

Table 8.4 - Working sample size for Wales[38]

	2004	2005	2006	2007
Construction	85	85	24	<10
Catering	69	71	18	10
Motor Trade	38	40	16	10
Production	408	370	237	206
Property	23	22	14	10
Retail Trade	48	44	34	12
Other Services	522	541	125	101
Wholesale	51	53	24	25
Total	1,244	1,226	492	<384

Source: ARD2 and Capital Stock Dataset

Table 8.5 - Working sample size for England

	2004	2005	2006	2007
Construction	261	348	354	140
Catering	407	546	400	214
Motor Trade	186	248	218	107
Production	3,097	3,036	2,730	2,182
Property	143	158	149	118
Retail Trade	450	529	548	294
Other Services	2,676	3,196	2,538	1,723
Wholesale	674	694	633	425
Total	7,894	8,755	7,570	5,203

Source: ARD2 and Capital Stock Dataset

[38] Due to the sensitive nature of the data any cells less than 10 need to be censored. This explains the <10 figure for Construction in 2007 and the 'Total' number not being disclosed for 2007.

8.7.3 The model

We adopted the standard Cobb-Douglas production function as the basis for testing the impact of accessibility and peripherality. This model is widely used in both micro and macroeconomics to represent the relationship of inputs to outputs. In the simple model, output (Q) is determined by two inputs, capital (K) and labour (L). The basic model is represented by the log-log regression:

$$\ln Q = \ln \alpha + \beta \ln L + (1 - \beta) \ln K$$

Where α represents some exogenous factor that can affect output, such as a technological breakthrough (e.g. microchip, internet, e-mail) and β is an output elasticity which is explained in more detail in the Appendix.

To this standard production function we add a number of variables. Firstly we include the ratio of part-time to full-time workers to proxy for skill levels of firms, where available. It is expected that as the ratio of part-time to full-time workers increase the output levels of the firm will decline. In line with other work we also include a variable for the number of plants or local units each reporting unit has. It could be that having more plants in the business provides the opportunity for positive spill-over output effects since greater networking can exist between these plants. However it could equally be the case that having more plants results in far greater repetition and duplication processes that can decrease output. Since we are using firm level data it is also advisable to capture differences in industries by controlling for industry using standard international codes (SIC).

The final model is represented by,

$LnQ = \ln\alpha + \beta \ln L + (1-\beta) \ln K + \tau P + \theta i Xi$

Where P represents peripherality and Xi represents other variables (industry, number of local units and part-time/full-time employment ratio).

The sign of the coefficient τ is expected to be negative in that the more peripheral a firm the less it would benefit from proximity to economic mass. The value of the coefficient τ may be interpreted as the percentage change in productivity (LnQ) caused by a unit increase peripherality (P). So if τ = -0.02 then a 1 unit increase in peripherality P (moving further away from the economic mass) will results in a 0.02 per cent *reduction* in productivity.

8.7.4 The results of the estimations

The results of the estimations are summarised in Table 8.7d below, which shows the coefficient of the peripherality term in the estimated production function. In plain language, it indicates how productivity will change for a given change in peripherality. The peripherality variable was calculated for both Unitary Authorities and NUTS 3 areas[39], for four years and for all firms in England and Wales, firms in Wales and firms in S.E. Wales. In the case of NUTS3 areas, annual GVA data is available and this is used to calculate economic mass. However, GVA is not available at UA level and working population is used. There are three attributes of these peripherality coefficients to note: the

[39] NUTS 3 is a statistical boundary used by the European Union. In Wales, NUTS 3 areas are typically amalgams of two or three Unitary Authorities/

mathematical sign, the value and the significance, (denoted by the number of stars, see key at the bottom of the table).

As noted earlier, we would expect the sign to be negative, denoting that an increase in the peripherality of a firm will be associated with a reduction in its productivity. Following on from Table 8.3a above, reasons why this is likely to be the case are as follows.

Firms in more peripheral locations will have:

- reduced access to markets;
- reduced access to supplies and business services;
- reduced access to skills;
- less external economies of scale and agglomeration benefits;
- reduced access to innovative knowledge networks; and
- narrower lifestyle choice to aid recruitment and retention of senior executives.

In the estimations summarised in the table only one has a positive sign which is for South East Wales for 2004 when using the distance to working population as the measure of peripherality. Whilst this finding is counterintuitive, this coefficient is not individually significant and thus does not represent a good estimate within the model.

The value of the coefficient denotes the strength of the influence of firms' peripherality on productivity. The use of logged variables in the estimations allows partial elasticities to be deduced. In plain language, the coefficient tells us the percentage change in productivity that will result from a one percent change in peripherality. For example, the NUTS 3 area peripherality coefficient for firms in Wales in 2004 (the first figure in the table) signifies that a 1% increase in peripherality would be associated with a 0.034% reduction in productivity.

The significance indicates the likelihood that the observed relationship has not occurred by chance. Three stars indicate significance at the 1% level, indicating a less than 1% likelihood that the association between peripherality and productivity observed in the firms in the sample has occurred by chance. Put another way, we can be more than 99% certain that it is indeed peripherality that accounts for the variation in productivity among firms in different locations.

Table 8.6- Significance of peripherality in estimations

Peripherality (distance to GVA) by NUTS3	Wales	Wales & England	South-East Wales
2004	-0.034**	-0.006***	-0.033*
2005	-0.029**	-0.008***	-0.028
2006	-0.019	-0.007***	-0.051
2007	-0.002	-0.007***	-0.086**
Pooled	-0.008	-0.007***	-0.040**

Peripherality (distance to working population) by UA	Wales	Wales & England	South-East Wales
2004	-0.011*	-0.001*	0.007
2005	-0.004	-0.003***	-0.002
2006	-0.002	-0.003***	-0.004
2007	-0.005	-0.002**	-0.013
Pooled	-0.006	-0.003***	-0.009

*, **, *** significant at 10%, 5% and 1% level.

The first point of note in the table above is the predominantly higher value of the peripherality coefficient for Wales and S.E.Wales than for England and Wales combined. This suggests that peripherality is more of an issue for firms in Wales than in England and that reduction in peripherality will have a greater impact on productivity in Wales than in England. There is some suggestion that peripherality has a greater impact on productivity in S.E.Wales than for Wales as a whole.

It is also notable that peripherality calculated at the UA level weighted by working population does not appear to be a significant determinant of productivity while peripherality calculated at the NUTS3 level weighted by GVA is. The reason for this is probably that proximity to GVA is more closely associated with locational advantage than proximity to working population. Proximity to where people travel to for work, to where other firms are based and where people shop and take their leisure, areas of concentrated economic activity, is more advantageous to firms than proximity to where working people live, residential areas. At the highly disaggregated UA level, residential areas and the associated areas of concentrated economic activity are often in separate UAs. Thus peripherality based on UAs and working population is not an effective measure of proximity to economic mass. On the other hand, NUTS3 areas are larger and often cover both areas of economic activity and the residential districts in which people employed in these areas live. Further, GVA is a better indicator of the level of economic activity than working population.

In considering which estimation should be used as the best indicator of the relationship between peripherality and productivity, where possible, the results for S.E. Wales should be used as this is the focus of this research. Fortunately, there are three significant results for peripherality calculated at the NUTS 3 level weighted by GVA; these are for years 2004, 2007 and the pooled estimate. The three coefficients are used to give a range of forecasts of toll impact below. They indicate that a 1% reduction in peripherality would lead to an increase in productivity of 0.033%, 0.086% and 0.04% respectively.

These three coefficients provide a range within which the productivity relationship is expected to lie and provide a basis upon which to estimate the impact of the tolls. Based on the results of previous studies and the result of the 'pooled' data estimate, it would be reasonable to suggest that the relationship is towards the lower end of this range. Therefore, the impact estimate is based on the assumption that **a 1% reduction in peripherality is associated with an increase in productivity of 0.033%**.

8.7.5 Limitations of the estimates

As noted, the methods employed in this Section are exploratory and the results are intended to be illustrative rather than accurate estimates of the overall economic impact of the tolls. There are a number of limitations of the estimates. The main limitations are as follows:

- A key issue is selection bias. The firms that locate in areas with poor accessibility are not representative of the generality of firms. They may well be low productivity firms whose operations are less dependent on good transport infrastructure, perhaps serving local markets or based in service sectors with limited physical inputs and outputs and no need to tap into a wide geographical market for higher level skills. Such firms might not exhibit any significant increase in productivity as a result of infrastructure improvement. On the other hand, it is likely that the structure of the local economy will change following infrastructure improvements and over time higher productivity firms more dependent on good physical communications with national and global markets will locate in the area increasing average productivity. The issue of selection bias is referred to again below;
- Omitted variable bias may influence the apparent significance of the peripherality variable. The degree to which the specification of the model and the proxy variables employed successfully capture all the variation in productivity across different areas other than that explained by peripherality. In particular, the ratio of full time to part time workers is an imperfect proxy for skills levels;
- Small sample sizes lead to inconsistency across years. The small sample size also leads us to have to use a coarse breakdown by sector so that considerable heterogeneity remains within sectors with the result that we are limited in our ability to correct for such structural effects;
- A further problem exists with the endogeneity of inputs. This arises in our model where capital stock and labour are related – both tend to be more extensive the larger firm. It is difficult to tease out which is contributing what to the output of the firm. The conventional approach would be to use panel data and a fixed effects model. Although we have data for a number of years, this does not provide a panel as the composition of the sample changes from year to year, and;
- The ARD dataset used in this research generally assigns the firm location to the reporting unit, normally the headquarters of a multi-branch organisation. This can be problematic in that the level of activity recorded applies in part to branches of the business located in other areas. Although there are some exceptions, generally UK business headquarters are not based in Wales and the extent of this distortion is inlikely to be extensive enough to invalidate our results.

The implication of the above issues is that, with respect to the productivity-peripherality relationship, there is significant variation in the results found for different years. Therefore, it is only possible to draw broad conclusions about the magnitude of the effects and caution should be used when interpreting the results.

8.7.6 Comparison with previous estimates of economic impact of transport infrastructure investment

The most relevant benchmark for comparison of our results are the agglomeration elasticities for UK sectors derived by Graham (2007) which form the basis DfT Transport Appraisal Guidance. These show much greater elasticities in service sectors than manufacturing and give a weighted overall elasticity for the UK of 0.125. This can be interpreted as a 10% increase in agglomeration would be associated with a 1.25% increase in productivity. This is a greater impact than the 0.33% increase in productivity we estimate would be associated with a 10% reduction in peripherality. However Graham's agglomeration measure and the peripherality measure used here differ significantly both in terms of the proximity element and the economic mass element. The agglomeration measure is ward employment density combined with a measure of distance and travel time to other wards weighted by employment density. Graham's measure can be characterised as local and regional while peripherality aims to capture inter-regional proximity as well. In later work, Graham (2010) emphasises the attenuation of impact on productivity with distance and derives agglomeration elasticities closer in numerical value to our peripherality elasticities.

Another study for the Northern Way uses a different approach employing a structural model. This shows that reducing journey time between Leeds and Manchester by 20 minutes (approx. 1/3) increases GDP/worker by up to 0.16%, although this impact is greatest in NE Yorkshire and is only up to 0.07% for Manchester. Reducing journey time between Manchester and London by 40mins (approx. 20%) increases GDP by up to 0.045% in both the Manchester area and Greater London but productivity in NE Yorkshire is reduced. A similar reduction in journey time between Leeds and London increases productivity around Leeds and Greater London by up to 0.054% but reduces productivity south of Manchester. These suggest an impact that is weaker than we calculate for peripherality although, once again, the methodology is different.

8.8 The impact of bridge tolls scenarios on peripherality

Peripherality was calculated taking into account three toll scenarios: no tolls, tolls being reduced by 50% and tolls being increased by 50%. Delay at the tolling point was also included expressing the combined impact in terms of generalised travel cost. As the tolls are different for different classes of vehicle, the generalised cost figure included an average of the three toll levels weighted by the traffic volumes of the three vehicle classes. The percentage change in peripherality associated with the three toll change scenarios is given in Table 8.8 below.

The impact of toll changes becomes more marked the closer the area is to the crossings. This is a direct effect of the distance-decay characteristics of the

gravity formulation of the peripherality variable: the further away economic mass is situated, the weaker the influence on economic performance. Thus toll reductions bring a marked increase in access to the economic mass of the West of England sub-region which is close to Monmouthshire and Newport and this exerts a powerful influence. In the case of South West Wales, the greater distance from the crossing means that the influence is sharply diminished. It should also be noted that the relatively high figure for Cardiff and the Vale of Glamorgan compared with the Central Valleys reflects the good access to the M4 of the former and the relatively poor access of parts of the latter.

Table 8.7- Percentage change in peripherality under toll change scenarios

Percentage change in peripherality of NUTS 3 areas			
% change from current tolls	**No Tolls**	**50% reduction**	**50% increase**
South West Wales	-4.00	-1.85	1.60
Bridgend and Neath Port Talbot	-7.68	-6.10	5.12
Cardiff and Vale of Glamorgan	-20.80	-8.01	6.49
Central Valleys	-12.99	-6.68	5.46
Gwent Valleys	-14.80	-6.36	5.02
Monmouthshire and Newport	-21.97	-7.99	6.03
	-14.53	**-6.43**	**5.19**

8.9 The impact of peripherality changes on the productivity of firms in South Wales

Bringing together the impact of peripherality on productivity and the impact of toll changes on productivity, we can estimate a range of percentage change in productivity as shown in Table 8.9. The total estimates for South Wales are the sum of NUTS3 productivity changes weighted by working population. **The results suggest that removing the tolls would boost productivity by in the order of 0.48% which would translate to an increase the annual GVA of South Wales of around £107m.** Based on the fact that GVA impacts are likely to be associated with structural changes in the economy as well as improved performance of existing firms, and given the conclusions relating to the gradual response of traffic flows, the impacts would be likely to accrue over the medium to long term (up to perhaps 15 years) but thereafter would represent a permanent increase in economic activity compared with the level of economic activity should the tolls be maintained at the current real level.

Table 8.8- Estimated change in GVA given different toll scenarios

Percentage change in GVA/FTE associated with toll scenarios	No tolls			Tolls less 50%			Tolls plus 50%		
Estimate	High	Mid	Low	High	Mid	Low	High	Mid	Low
South West Wales	0.34	0.16	0.13	0.16	0.07	0.06	-0.14	-0.06	-0.05
Bridgend and Neath Port Talbot	0.66	0.31	0.25	0.52	0.24	0.20	-0.44	-0.20	-0.17
Cardiff and Vale of Glamorgan	1.79	0.83	0.69	0.69	0.32	0.26	-0.56	-0.26	-0.21
Central Valleys	1.12	0.52	0.43	0.57	0.27	0.22	-0.47	-0.22	-0.18
Gwent Valleys	1.27	0.59	0.49	0.55	0.25	0.21	-0.43	-0.20	-0.17
Monmouthshire and Newport	1.89	0.88	0.73	0.69	0.32	0.26	-0.52	-0.24	-0.20
Total South Wales	**1.25**	**0.58**	**0.48**	**0.55**	**0.26**	**0.24**	**-0.45**	**-0.21**	**-0.17**

It is useful to briefly consider the magnitude of the GVA impact in relation to the direct costs of the toll. The estimated effect on GVA of £107m compares with direct toll costs for users of some £80m per annum in 2010 (adjusted for reclaimed VAT). The results suggest a potential 'multiplier' of around 1.3. In comparison, the results of other studies (employing Department for Transport guidance) suggest that wider benefits typically represent some 10% to 30% of direct benefits.

There are a number of caveats to the comparison of the results presented in this study and the magnitude of productivity effects of transport improvements measured using the Department for Transport's approach. In particular it should be considered that the direct impact of abolishing tolls would accrue to those whose journeys originate in Wales and those based to the east of the crossings. An initial view might be that only perhaps half of the direct effects would accrue to the economy of Wales. However, journeys originating to the east are also likely to be associated with benefits to the economy of S.E. Wales as they may well be associated with business inputs and recreational visits and be enhanced through toll reductions.

The discussion summarised in Table 8.3a above suggests that our peripherality-productivity relationship is capturing some direct as well as some wider benefits. If this is the case, then our 'multiplier' value appears reasonable. However, this ignores the likelihood that the full economic impact would not fully materialise for some 15 years. If the benefits of abolishing the tolls in terms of greater GVA and the costs in terms of revenue forgone were subject to discounted cash flow appraisal, the Net Present Value of toll abolition would be negative, and not an attractive proposition.

In conclusion, the results of the modelling indicate that the tolls do have a measurable impact on overall economic performance. The results further suggest that, due to a range of indirect effects, the overall economic impact may be in excess of the direct cost of the toll. However, caution should be applied in drawing precise conclusions as to the magnitude of GVA impacts through economic modelling techniques.

9 Conclusions

The key findings of the study are as follows:

Direct Costs of the Severn Tolls

1. The tolls increase the cost of journeys between South Wales and parts of the South and South West of England. The proportion of *total journey cost* accounted for by the toll varies greatly across different types of user. For a car journey (excluding commuters and business travel) the toll represents, on average, approximately 19% of trip costs for a journey between Cardiff and Bristol[40]. For a business traveller, considering the value of lost productive time, toll costs fall to, on average approximately 8% of trip costs. For goods vehicles making the equivalent journey, tolls represent around 23% of total journey costs for a light goods vehicle and 21% for a heavy goods vehicle. The proportionate impact of the toll falls with distance travelled.

2. Total revenue from the tolls (both crossings combined) in 2010 amounted to £76m. Taking all goods vehicles toll payments and toll payments of business users, the direct toll costs imposed on businesses can be roughly estimated to be £47m (excluding VAT) in 2009 prices, with remaining £34m (including VAT) being paid by consumers. Therefore the total cost to businesses and consumers, once VAT is taken into account, is in excess of £80m a year.

3. There are further direct costs imposed by the toll due to the time related costs of the stop-start delay at the toll booths and the impact on drivers taking alternative routes and therefore experiencing longer journey times and costs. Conversely, tolls and user charges are often associated with having congestion relieving effects which serve to reduce congestion and improve journey times for other users who are willing to pay tolls. Whilst this is not a major factor for the Severn Crossings (given that the Crossings themselves operate well within capacity), traffic modelling suggests that the tolls are likely to have a minor positive effect on traffic flows elsewhere on the network.

Impacts on Traffic and Transport

4. A high level traffic analysis was undertaken for each of the scenarios for the years 2018, 2023 and 2028. These provide approximate estimates of changes in traffic flows based on the modelling. The headline results under each scenario show that reducing the tolls by 50% would result in an estimated increase in total traffic (as against a 'do minimum' scenario similar to the existing toll charges) in the order of 5% based on predicted conditions in 2018. Removing the tolls entirely (as well as eliminating any toll collection delay[41]) would result in an estimated increase in traffic across of 12%. This is equivalent to around 11,000 vehicles per day. An increase in the toll of 50% is estimated to reduce traffic by nearly 5%. In reality, traffic responses are dynamic and users' behaviour will adjust over a period of time.

[40] Based on the Cardiff to Bristol leg of a return trip assuming half the toll cost applies to each leg, under average morning peak conditions.
[41] The delay experienced by users at the toll booth is likely to vary greatly across the day/week/year. It has only been possible to employ a rudimentary approach to incorporating the effects of toll booth delay based on observations undertaken in the spring of 2007.

5. The above changes in traffic demand have been applied to recent data on SRC plc toll revenue in order to understand the financial implications of the scenarios[42]. The *reduction* in revenue if the toll were halved is estimated to be approximately £36m per annum (2009 prices), a 46% reduction. An increase in the toll of 50% would result in *additional* revenue of around £36m per annum, a 41% increase. In each case, the change in revenue is less than proportional to the change in toll because of the offsetting effect of higher or lower traffic flows.

Impacts on Business Performance and Location

6. The research confirms the importance of the Severn Crossings for businesses in South Wales. Of those businesses surveyed, 50% considered the crossings to be either 'important' or 'very important' for their business. The proportion of businesses for which the tolls are 'significant' is a substantial minority, with 12% reporting the tolls to be significant and 8% reporting the tolls are highly significant. The importance placed on the tolls was closely related to the particular sector, location and operating structure of the firm in question. Not unexpectedly, businesses based in South Wales are more likely to place importance on the crossings and the tolls than businesses based in the South West of England.

7. The significance of toll costs, however, must be seen in the context of overall operating costs. For the vast majority of businesses direct toll costs represent a very small proportion of total costs. For the service sector and high value manufacturing firms, transport costs typically make up a small proportion of overall costs and therefore toll charges are of diminishing importance. The exception is transport and logistics businesses predominantly engaged in trade between the South and West England and South Wales. An illustrative analysis suggests that toll costs could, in the most extreme cases amount to between 5% and 10% of annual vehicle operating costs[43] for freight vehicles. Given that profit margins tend to be relatively low in this sector, the implications for business performance and profitability can be significant where a firm is predominantly engaged in 'cross-Severn' goods transport.

8. It should be considered that the tolls could be expected to deter competition in local markets as well as providing a barrier for Welsh businesses when competing in England, although the relative size of the two markets is such that any 'barrier to trade' is likely to be felt more keenly by business in South Wales. Based on the analysis of the survey responses, businesses were more likely to report that tolls affected their cost base and profitability than they were to suggest that the tolls deter customers or place their business at a disadvantage, in comparison with businesses located in England, when competing in particular markets.

9. Location decisions are highly complex and businesses will consider access to markets, access to skills, wage costs, costs of land and property. As with previous reports into the tolls, whilst it was established that some businesses

[42] Estimated changes in toll levels and traffic flows have been applied to the latest available data on Severn Crossing revenue from 2009 taken from SRC plc Annual Reports. The analysis assumes that SRC plc revenue is unchanged in real terms from 2009 and ignores the effect of changes in demand between 2009 and 2018.

[43] Vehicle operating costs includes fuel costs, vehicle operating costs, wages, overheads and other costs such as vehicle licensing.

pay regard toll costs when considering locations in Wales, no instances could be identified where toll costs were pivotal in a decision not to locate in Wales. In the specific case of Regional Distribution Centres , when choosing a location it is typical to undertake a detailed cost-benefit assessment of potential locations which takes into account all operating costs including tolls. On this basis, it is possible to imagine a situation in which the tolls contribute to a decision to locate outside South Wales. However, given the wage and fuel costs associated with journeys across the estuary notwithstanding the tolls, in most cases proximity (to the M5 corridor for example) is likely to be a more significant factor than the tolls themselves.

Impacts on the retail, tourism and leisure sectors

10. As with tolls and business location, the significance of the tolls in determining visitor's travel decisions should be seen in the context of total trip costs. From this perspective, toll costs are likely to be significant mainly for trips of a short duration, such as day trips and shopping trips, and where the distances travelled are relatively short. For longer distance trips and overnight stays, the toll is likely to be a small proportion of the total costs of a visit. Therefore, higher value tourism is less likely to be affected.

11. A survey of households in South West England was undertaken to help better understand the impact of the tolls on the perceptions of potential visitors to Wales. When asked if they would expect to make more trips to Wales by car if the Severn tolls are removed, 22% of surveyed residents of South West England said they would expect to make more trips to Wales in the next twelve months. Whilst survey responses of this nature are potentially subject to bias, the results might suggest that removing tolls would encourage more visits to Wales. Notably, the proportion of respondents expressing this view falls with distance from the crossings, perhaps supporting the assertion above that tolls are more likely to influence trips of a shorter duration.

12. It should, however, be considered that the tolls might be expected to deter trips in either direction. Therefore, the net effect on the Welsh visitor economy could be positive or negative. Given the importance of the visitor economy in Wales and the increasing importance of Cardiff as a retail destination (relative to Bristol for example), it is considered likely that the net effect of the tolls is, on balance, negative.

13. A further consideration, raised by tourism industry representatives, is whether toll negatively affects the way people *perceive* Wales as a visitor destination and whether this has an effect disproportionate to the financial cost of the toll. For, example, the cost and inconvenience of the toll were highlighted as potential issues during the 2010 Ryder Cup when tourism bodies were seeking to encourage return visits. However, effects on perceptions are difficult to measure or to separate from other factors and there is no firm evidence on the link between tolls, perceptions and propensity to holiday in Wales.

Impacts on the Labour Market

14. Based on the current toll cost of £5.70 per vehicle, a simple analysis would suggest that toll costs for a commuter crossing the Severn each working day would amount to around £1,400 over a year[44]. For a commuter trip between

[44] Based on one crossing for each working day – 240 crossings at £5.70 gives £1,368.

Newport and Bristol, the toll accounts for approximately one quarter of total journey costs. As such, the tolls represent a potentially significant deterrent to commuting between South Wales and the South East of England.

15. Evidence from the 2001 census showed around 6,600 workers commuting from the Welsh Severnside[45] area to the English Severnside[46] with a further 8,500 travelling to work in other parts of England. There is a directional imbalance in commuting across the Severn with around 2,000 commuters travelling in the opposite direction from the English Severnside to the Welsh Severnside.

16. The traffic analysis suggested that removing the tolls would result in an increase in commuting across the Severn Crossings of 11% (excluding reassignment of traffic). Changes in commuting patterns will take time to play out and this should be considered a long term adjustment. This degree of change could represent upward of 1,000 commuters. However, this result is based on general observations of transport user behaviour and is a relatively crude measure. Local labour markets are complex and individuals make typically make their commuting decisions based on a range of factors. Mobility, recruitment and job search geographies vary by sector and by occupation. Individuals make typically make their commuting decisions based on the balance of wage and job differentials between home and work locations, differences in the cost of living / quality of life and the costs of mobility.

17. Some inferences can be made based on the existing profile of commuters. Firstly, the existing directional imbalance and the differential in wage rates between the English Severnside and the Welsh Severnside might suggest the greatest part of any increase in commuting would relate to residents of Wales travelling to jobs in England. This effect could be reinforced by patterns of migration with more affordable house prices in Wales and the rural amenity of an area such as Monmouthshire which currently has the highest number of commuters into England of the South Wales Local Authorities.

18. Secondly, given the occupational profile of commuters and the fact that higher paid workers are typically more mobile than lower paid workers, it is likely that additional commuters will also be above average in terms of pay and skill levels. The inference from this is that the additional commuting is likely to primarily represent changing employment search areas or changing distribution of employment rather than any increase in participation rates.

Effects on Productivity

19. Exploratory economic modelling techniques have been employed to attempt to quantify the impact of the Severn tolls on the productivity of the South Wales economy. The analysis is intended to supplement the survey and other approaches through reference to statistical data on the relative performance of firms in Wales and England. The analysis builds on previous studies into the relationship between accessibility (broadly, proximity to economic mass) and economic performance.

[45] Welsh Severnside includes Cardiff, Newport, Monmouthshire, Caerphilly, and Torfaen
[46] 'English Severnside' includes Bath and North East Somerset, the City of Bristol, North Somerset, South Gloucestershire, and Stroud.

20. A peripherality variable has been constructed based on the cost of travel between all areas in the model. The research finds a statistically significant relationship between this measure of peripherality and firm productivity. The model indicates that a 1% reduction in peripherality would lead to an increase in productivity of 0.033%.

21. The peripherality variable has subsequently been adjusted to reflect conditions if the toll were to be removed after 2018. The impact of toll changes becomes more marked the closer the area is to the crossings. The results suggest that, based on the peripherality-productivity relationship, the tentative conclusion of the economic modelling exercise is that removing the tolls would boost productivity by in the order of 0.48% which would translate to an increase in the annual Gross Value Added (GVA) of South Wales of around £107m. This compared with 'direct' effects (reduced transport costs – i.e. toll payments) of some £80m giving a potential 'multiplier' of around 1.3. The results indicate that the indirect effects discussed elsewhere in this report are such that the overall impact of the toll exceeds the direct cost of the toll. However, caution should be applied in drawing precise conclusions the magnitude of GVA impacts through economic modelling techniques.

This study is the first comprehensive attempt to consider the effects of alternative futures for the tolls on the Severn Crossings. The study has highlighted the many complex impacts and issues related to Severn tolls. The tolls impose a cost on users of the Severn Crossing and therefore much on the analysis has focussed on the degree to which the tolls impact negatively on the economy. It is clear that such impacts are not evenly distributed across individuals, sectors or geography. The study has not attempted to consider the potential trade-offs or opportunities associated with re-investment of toll revenue following the end of the concession agreement. Furthermore, whilst the research has tested some relatively simple scenarios for the future of the tolls it has also highlighted interesting opportunities relating to alternative approaches to tolling – such as the level of toll for different vehicle types, discounts for regular use, variable tolls and new technology – which could mitigate against some of the negative impacts highlighted in this report.

Appendix A

Traffic Modelling Approach

A1 Traffic Modelling Approach

A1.1 Background

A traffic model has been used to estimate the effects of the tolls on the Severn Crossings on travel demand and travel patterns. This is achieved by comparing a range of future scenarios for the tolls. The defined scenarios are as follows:

1. Scenario 1 – Reduction in tolls by 50% in real terms
2. Scenario 2 – Removal of tolls
3. Scenario 3 – Increase tolls by 50%

Each of the above scenarios are tested against at do minimum situation under which the current tolling regime is assumed to continue to toll levels the same, in real terms, as current. Changes in the tolling regime (under Scenarios 1, 2 and 3) are assumed to take place in 2018 following the end of the concession arrangement.

A1.1.1 Key Issues

Modelling the effect of tolls requires us to consider a number of key technical challenges:

- **Lack of historical toll changes** – tolls have always been in place on the Severn Crossings. Since the construction of the Second Severn Crossing, tolls have been fixed in real terms only varying on an annual basis in line with the RPI. Therefore, there are no historical changes for which traffic responses can be analysed;
- **The lack of empirical data specific to toll elasticities** – toll roads and bridges are relatively rare, therefore the literature (particularly *ex-post* assessments) on toll responses and elasticities is limited. Importantly, toll responses are highly context specific and it is therefore difficult to transfer experience from elsewhere to the Severn Crossings;
- **The response of goods vehicles** – empirical data is also lacking on the demand response of goods vehicle traffic to changes in transport costs. Typically, modelling of transport projects assumes the overall level of demand (or the total number of goods vehicles trips) is fixed. With this approach, changes in transport cost only impact on the route choices of goods vehicles. In the case of the Severn Crossings, although demand is likely to be highly inelastic, it may be the case that the tolls affect the number, distribution or frequency of trips through South Wales, although the magnitude of such changes are difficult to model;
- **The effect of 'one-way' tolling** – most journeys are return trips, or 'tours', that start and end in the same place, usually at the home. The traffic model we have proposed to use for this study is an assignment model with journeys represented as one-way trip legs, not tours. This is normal practice for traffic assignment. For demand modelling though, it is necessary to consider the tour or return trip. For most toll situations, tours may be divided into two very similar half-tours as tolls are usually applied in both directions. In the case of

the Severn Bridges, the charge is levied in the westbound direction only. For assignment (route choice), this presents no problem. But for demand modelling, it is important to understand that removal of the westbound toll will affect both east and westbound demand, given that driver decisions are made for the entire tour, not just one half of it. In practice this can be represented by selecting tours as the demand unit (if suitable data are available), or by applying a half toll to both directions as an approximation;

- **Complexity of toll responses** – in reality, the response to tolls is highly complex and modelled approaches by definition average out a great deal of variation in behaviour. The overall change in traffic movements over the bridges in response to changes in tolling will be made up of a range of responses and behaviours, including route choice, mode choice, decisions about where to work, shop or visit, frequency of trips and effects on the business or housing location. The traffic model simplifies this complexity through the application over overall responses to transport costs;
- **Modelling dynamic effects** – the above responses are dynamic and time dependent. In reality, following a change in the tolling regime, some changes in behaviour will be immediate or will occur in the short term (for example, a shopper choosing an alternative shopping centre), other changes in behaviour may take longer to adjust (such as a decision to choose alternative modes of travel), and some changes will take place over a much longer timescale (for example, the decision to search for employment over a wider area, or changes in land use and housing location). However, the traffic model is a simplification of reality and is essentially static. The model assumes drivers have perfect knowledge (for example about the traffic conditions and travel times on all parts of the network) and changes in route choice and demand are immediate; and
- **Economic impacts and transport responses** – the changes in transport behaviour noted above have economic impacts and vice versa. The impact of the tolls on productivity and business location is modelled elsewhere in this report. Such changes have significant implications for traffic volumes. However, given the complexity of these impacts and behaviours, no attempt has been made to link the traffic and economic modelling such that economic effects feedback into the traffic model. Changes in traffic flows predicted by the traffic model are compatible with impacts on economic performance predicted by the economic model.

A1.2 Traffic Model

The M4 SATURN traffic model is the primary traffic model used for this study. It is the most suitable model because of its detail and coverage. It is the only traffic model available which covers both South East Wales and the South West Avon. Arup has used the model as a tool to produce traffic forecasts to inform the economic, environmental and operational aspects of proposed highway schemes in the study area. Both the base model and the resulting traffic forecasts have been the subject of an independent audit, and deemed satisfactory, by Transport Research Laboratory (TRL).

The ‘core area’ of this traffic model covers the strategic highway network in south east Wales to a high level of detail. This area extends from Junction 30 of the M4 in Cardiff to Junction 21 of the M4 to the east of the Severn Estuary. Outside this core area is a large area of influence that is modelled at a lower level of detail,

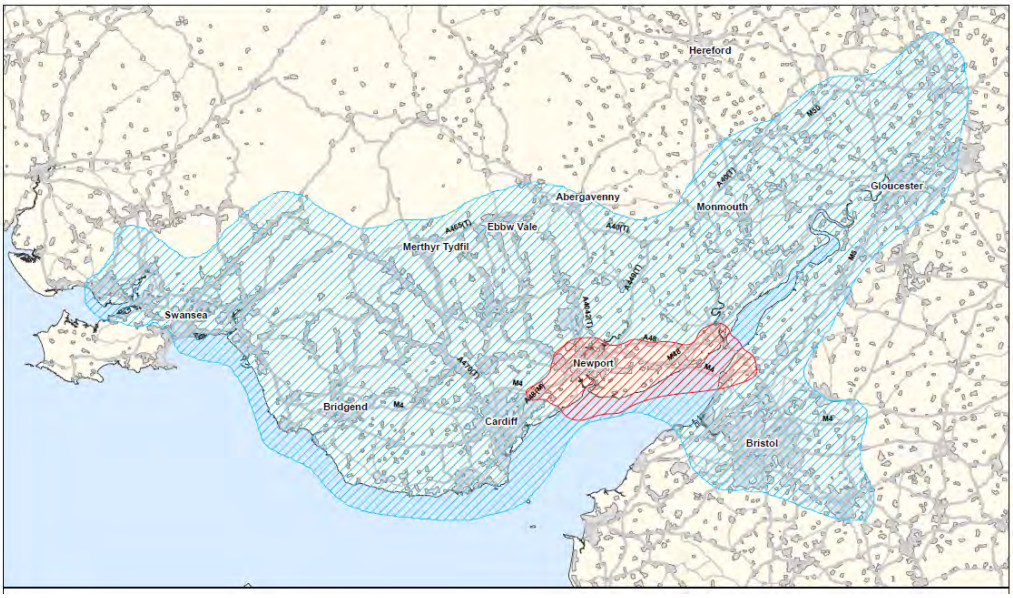
although even outside this area origins and destinations of vehicles can still be determined at, at least, regional level.

This traffic model was further refined for the purposes of this study, whereby the modelled traffic flows crossing the Severn Estuary were factored to more closely match observed traffic flows in this specific location. The proportional split according to vehicle type and by direction were adjusted according to the splits observed during manual classified traffic counts undertaken on the Severn Bridges in 2003. These were then factored further to bring the overall volumes in line with 2005 levels based on automatic traffic count data. Refinements to the 2005 base year traffic model in the area of the Severn Estuary were incorporated into the traffic forecasting in order to provide the best representation of likely future year traffic conditions in the study area.

A1.2.1 Model Update

The model has been calibrated for the years 2010, 2018, 2023 and 2028. The current (2010) and future year model has been updated to reflect changes in traffic flows across the bridges since 2005 using count data provided by Traffic Wales. Future growth in traffic is based on TEMPRO factors for the National Transport Model provided by the Department for Transport. In the absence of a large scale primary data collection exercise, travel patterns (origins and destinations of travel) have not been altered in the model.

Figure A1.1 - M4 Traffic Model - Core Area and Wider Area of Influence



A1.3 Values of Time and Operating Costs

A1.3.1 Values of time and toll penalties

Total transport costs for road users are comprised of fuel costs, vehicle operating costs (tyre wear for example), fares or toll costs, in addition to the opportunity cost of lost working or leisure time. To calculate the total costs of transport financial costs and time related costs need to be converted into a consistent unit, in this case 'generalised time'. This requires an understanding of the relationship between time and costs, in other words user's Value of Time (VOT).

The effect of the tolls on the behaviour of users can only be assessed by considering toll costs alongside other costs. The 'penalty' for trips crossing either of the Severn Bridges is applied as the effect of the toll on the generalised time of travel, in the form:

Equation (1)

$$GT_{ijs} = DriveTime_{ij} + \frac{VoC_{ij} + Toll_{ij}}{VoT_s}$$

Where: GT is Generalised Time; VoC is vehicle operating costs; VoT is value of time; subscript ij denotes origin-to-destination zone, and subscript s denotes the demand segment.

In order to convert to a consistent unit of measure (generalised time), the financial cost of the toll is translated into a time penalty based on users' values of time.

Values of time tend to increase over time in real terms as incomes rise. The cost of the toll increases (and is assumed to continue to do so in the future) in line with RPI. Therefore, the calculated toll penalty (and the relative importance of the toll against other costs falls. This is reinforced by assumption that fuel prices will increase at a faster rate than general inflation over the period to 2028.

A1.3.2 Demand Model Formulation – Elastic Response to Transport Costs

An elasticity model has been employed to amend demand in response to changes in the toll, vehicle operating costs and driving time. While the focus of the project in on the effect of a changing toll, it is inevitable that changes in vehicle operating costs and congestion levels will accompany this, and these effects are also embodied within the overall change in generalised costs.

The arc elasticity formulation as given in WebTAG Unit 3.10.4 has been used on this basis and is given below:

Equation (2)

$$Demand(1)_{ijs} = Demand(0)_{ijs} \times \left(\frac{GT(1)_{ijs}}{GT(0)_{ijs}}\right)^{e(s)}$$

The arc elasticity, e, is defined as:

Equation (3)

$$e = (\log(Demand^1)-\log(Demand^0))/(\log(GT^1)-\log(GT^0))$$

Where: (0) denotes 'base' scenario with current toll; (1) denotes 'forecast' scenario with amended toll; e is the elasticity of demand with respect to generalised time; and (s) denotes demand segment.

A1.3.3 Modelling Process

As noted, values of time are used in traffic modelling to equate time costs and financial costs. Financial costs include toll costs, but also other financial costs: fuel costs and vehicle operating costs (for example, tyre wear). There are two elements within the traffic model through which changes in transport costs (generalised time) are represented. The first element is the ***assignment model*** which calculates the most efficient (least costly in terms of generalised time) route through the network for travel between any origin and destination. The second element is the ***demand adjustment***, which predicts changes in demand for travel between origins and destinations based on the generalised time of travel. Tolls affect both the assignment model (by making the tolled route more costly relative to other routes) and the demand model (by increasing the costs of travel between origins and destinations which are affected by the toll.

It should also be noted that the traffic model takes into account any effect of tolling on the level and flow of traffic. For example, if tolls are reduced, this may have the effect of increasing the level of traffic on the tolled route or other routes (due to some combination of demand and assignment effects) which could in turn reduce traffic speeds (due to increased congestion), leading to increased travel times. Therefore, all other things being equal, changes in demand due to tolls will be (partly) offset by higher or lower congestion.

The modelling works on an iterative basis. The steps in the modelling process are therefore as follows:

- **Step 1 – Baseline assignment** – the model calculates the routes in the model which minimise generalised time for all origins and destinations and 'assigns' baseline demand through the network;
- **Step 2 – Adjusted toll assignment** – changes in the toll are reflected by adjusting the toll penalty applied to journeys over the bridges. Generalised time minimising routes are re-calculated;
- **Step 3 – Demand response (variable demand calculation)** – Equation 3 is applied under the adjusted toll scenario resulting in changes in demand for origins and destinations using the bridges; and
- **Step 4 – Iteration** – changes in traffic and traffic speed resulting from Step 3 feedback into the assignment model through changes in generalised time and, in turn, impacts on demand through equation 3.

The process continues until a stable solution is found.

A1.4 Empirical basis

A1.4.1 Values of Time estimates

The values of time employed in the model are based on two sources: Department for Transport recommended values of time for various category of road user weighted by values of time derived from a 2005 Stated Preference (SP) survey undertaken to assess the potential demand for a proposed tolled M4 relief road around Newport.

The SP survey asked drivers to choose between various scenarios for a tolled M4 relief road. Respondents were asked to choose between paying to use a toll road or remaining on the untolled road network and suffer the penalty of a longer journey. In effect, the SP survey estimates users willingness to pay for time saving, or their value of time.

The advantage of using the results of the SP survey, rather than taking UK average values of time (published in WebTAG), is that the values are specific to M4 users. In this regard they provide a more locally tailored picture of the value of time.

Conversely, the values of time from the SP survey were derived for a very specific set of choices in relation to two alternative motorways, one faster tolled route and another slower untolled route. The SP survey sought responses from drivers using the M4 around Newport, not the Severn Bridges themselves. It is also the case that responses to SP surveys may be subject to bias if user's preconceptions of tolls influence their response to the choices presented to them, therefore producing potentially biased estimates of VOTs.

WebTAG values of time are derived from the National Transport Survey and are based on income levels. The advantage of using WebTAG values of time are that they have a stronger empirical basis and are not subject to the bias or variation of a single SP survey. However, they are based on UK averages for road users and therefore fail to reflect the profile of M4 users specifically.

The overall values of time estimates from the SP survey were shown to be broadly in line with those in WebTAG Unit 3.5.6. Only estimates for business users were significantly lower than the values prescribed by WebTAG. This difference in the estimates for employers business can only be partly explained by lower average wages in South Wales than the UK average.

Table A1.1 Values of Time (Webtag vs M4 Stated Preference Survey), £'s per Hour, 2005 values and prices

Segment	Webtag	New M4 SP
Car Business	£23.21	£9.88
Car Commute	£5.35	£4.80
Car Other	£4.73	£6.30
LGV	£8.94	£9.90
HGV	£8.94	£10.46

A1.4.2 User class segmentation

The M4 traffic model distinguishes between five different types of vehicle, or user classes. These user classes comprise three groups of car user (business travellers, commuters and other) in addition to light and heavy goods vehicles. However, this approach averages out a great deal of variation within each user class. By segmenting these user classes further, based on journey distance and income, we are able to model traffic responses more closely tailored to the profile of traffic crossing the bridge. The following 14 user classes were defined and specific elasticities estimated for each of these user classes for the purposes of the SP study.

Table A1.2 User Class Definition

Segment	Vehicle Type	Journey Purpose	Annual Income	Trip Time
1	Car	Business	Under £30,000	Under 3 hours
2	Car	Business	Over £30,000	Under 3 hours
3	Car	Business	Under £30,000	Over 3 hours
4	Car	Business	Over £30,000	Over 3 hours
5	Car	Commute	Under £30,000	Under 1 hour
6	Car	Commute	Over £30,000	Under 1 hour
7	Car	Commute	Under £30,000	Over 1 hour
8	Car	Commute	Over £30,000	Over 1 hour
9	Car	Other	Under £30,000	Under 30 mins
10	Car	Other	Over £30,000	Under 30 mins
11	Car	Other	Under £30,000	Over 30 mins
12	Car	Other	Over £30,000	Over 30 mins
13	LGV	All	All	All
14	HGV	All	All	All

A1.4.3 A hybrid approach

A hybrid approach has been taken which makes use of the detailed user class breakdown provided by the SP survey but constrains the overall weighted average values of time for each user class to the values provided by WebTAG. Therefore, the values of time reflect UK averages but *variance* in the value of time for each sub-group is based on the M4 SP user survey. This is summarised in the formula below:

Equation (4)

$$VOT\ p,l,i = WebTAG\ VOTp \times \left(\frac{M4\ SP\ VOT\ p,l,i}{M4\ SP\ VOT\ p}\right)$$

Where: VOT denotes Value of Time for each trip purpose (p) trip length (l) and income band (i).

A further refinement has been applied to employers' business trips to reflect differences in wage rates in the 'Severnside'[47] area relative to the UK average. Gross weekly pay for full time workers in the Severnside area is 96% of the UK average.

The resultant values of time are illustrated in Table A1.3.

Table A1.3 - Values of Time (£s per hour, 2005 values and prices)

Purpose	Trip Length	Income Band	% of trips (2005 base model)	WebTAG value of time	M4 Stated Preference survey value of time	'Hybrid' Approach: *M4 Stated Preference survey value of time constrained to WebTAG averages*	Weighted to Reflect Lower Wage Rates in Study Area in Comparison with UK average
Commute	Short	Low	27%		3.72	4.14	6.66
		High	29%		5.82	6.48	10.41
	Long	Low	21%	**5.35**	3.72	4.14	6.66
		High	22%		5.82	6.48	10.41
	Weighted Average				4.81	**5.35**	**4.81**
Business	Short	Low	26%		6.84	16.07	NA
		High	45%		8.82	20.72	NA
	Long	Low	11%	**23.21**	12.06	28.33	NA
		High	18%		15.54	36.50	NA
	Average				9.88	**23.21**	NA
Other	Short	Low	7%		5.84	4.39	NA
		High	4%		7.13	5.36	NA
	Long	Low	57%	**4.73**	5.84	4.39	NA
		High	32%		7.13	5.36	NA
	Weighted Average				6.31	**4.73**	NA
LGV	Weighted Average			**8.94**	9.90	**8.94**	NA
HGV	Weighted Average			**8.94**	10.46	**8.94**	NA

A1.4.4 Calculated Toll Penalties

As noted, the tolls are translated into a time penalty based on the user's value of time. The calculated time penalties are entered into the model as perceived by a user on one leg of a two-way trip. Therefore for a return journey the toll is halved and applied to each leg. It is assumed that business users (car, LGV and HGV) perceive the toll net of VAT because they are able to claim back this proportion. Other users perceive the toll including VAT.

[47] Monmouthshire and Newport, Cardiff and the Vale of Glamorgan, Bridgend and Neath Port Talbot, Central Valleys, Gwent Valleys, Swansea, Bristol, Bath and North East Somerset and South Gloucestershire.

Table A1.4 - Effective Toll 'Penalty' (2005)

User Class			Perceived Toll Cost (as two-way toll) CAT 1 - £4.80 CAT 2 - £9.60 CAT 3 - £14.30	Effective time penalty in Seconds (excluding toll booth delay)
Car Employers Business	Short distance	Low income	£2.04 (£2.40 less VAT)	1,075
		High income		834
	Long distance	Low income		610
		High income		473
Car Other	Short distance	Low income	£2.40	1,480
		High income		1,211
	Long distance	Low income		1,480
		High income		1,211
Car Commute	Short distance	Low income		2,323
		High income		1,485
	Long distance	Low income		2,323
		High income		1,485
LGV			£4.09 (£4.80 less VAT)	1,485
HGV			£6.09 (£7.15 less VAT)	2,093

A1.4.5 Vehicle Operating Costs

Fuel and non-fuel vehicle operating costs (pence per km) are taken from WebTAG Unit 3.5.6 for cars, LGVs and HGVs.

A1.4.6 Demand Elasticities

The overall responsiveness (elasticity) to changes in toll costs (or indeed generalised costs) incorporates and simplifies a complex range of user choices and responses including trip frequency, trip distribution and mode choice. The traffic model needs to be calibrated such that the elastic response ($e^{(s)}$) of demand (total vehicle kilometres travelled) reflects available empirical evidence. Two potential approaches to this have been considered.

The first approach is to impose the elasticity of demand based on evidence on toll elasticities. The advantage of this approach is that the elasticity used would be specific to user responses to tolls. However, the empirical evidence base is inadequate. In part this is because of the relative lack of toll elasticity studies that have been carried out. It is also the case that the toll elasticities in the literature are heavily influenced by the context of the tolled route, in particular the availability of alternative routes.

This study takes a second approach whereby the responsiveness (elasticity) to changes in transport costs (generalised time) has been calibrated to simulate the sensitivity of traffic demand to changes in fuel prices based on empirical data.

This implies that a pound saved on toll costs will have an equivalent impact on demand as a pound spent on fuel costs. This method follows the guidance on variable demand modelling given in WebTAG 3.10.4.

The disadvantage of this approach is that the influence of driver's perceptions of tolls is not reflected in the demand response. We acknowledge that stated preference surveys suggest that responses to tolls may differ from the response to other transport costs, although it is not always clear that the bias in responses is reflected in the reality of user's responses to tolls. Given that there is no systematic method or empirical basis for determining the significance of the influence of users' perceptions of tolls, it is considered that assuming equivalence between toll and fuel price elasticities is a reasonable approach.

A1.4.7 Empirical data

Empirical data for fuel price elasticities is better developed than for toll elasticities. Literature (see Graham and Glaister (2002), Goodwin et al (2002) and Hyman et al. (2002)) suggests a long term elasticity of car use (vehicle kms) with respect to fuel costs of around -0.3. Furthermore, WebTAG suggests that variable demand models should reflect more inelastic responses of employer business trips (of around -0.1) and more elastic responses for discretionary trips (around -0.4).

There is very little evidence for similar elasticities for goods vehicles. Most modelling approaches therefore assume fixed overall demand for LGVs and HGVs.

A1.4.8 Model Calibration Results

The elasticities for each user class within the M4 model are shown below following calibration of the model. The table shows the overall response of the demand to fuel price for the model as a whole at -0.3, and slightly less elastic responses for the core area, reflecting the profile of users and journeys on the M4 itself. Therefore, whilst the elasticity of total demand (vehicle kms) has been fixed to -0.3, the elasticity of the sub-set of users travelling over the bridges will be slightly less given the high proportion of longer journeys as well as the relatively high proportion of freight and business travel.

Table A1.5 - Travel cost elasticities calibrated to change in fuel price - model and core area (AM Peak)

User Class	Elasticity by user class			Overall model elasticity	Core area average elasticity	Daily Core area Model Elasticity	Daily Overall Model Elasticity
	AM						
	Trip Distance	Income	Elasticity				
Car Business	Short	Low	- 0.10	-0.27	-0.25	**-0.28**	**-0.30**
		High	- 0.07				
	Long	Low	- 0.23				
		High	- 0.08				
Car Other	Short	Low	- 0.41				
		High	- 0.39				
	Long	Low	- 0.48				
		High	- 0.46				
Car Commute	Short	Low	- 0.28				
		High	- 0.25				
	Long	Low	- 0.37				
		High	- 0.35				
LGV	- 0.31						
HGV	- 0.31						
Inter Peak							
Car Business	Short	Low	- 0.13	-0.32	-0.32		
		High	- 0.10				
	Long	Low	- 0.24				
		High	- 0.08				
Car Other	Short	Low	- 0.42				
		High	- 0.39				
	Long	Low	- 0.47				
		High	- 0.44				
Car Commute	Short	Low	- 0.31				
		High	- 0.28				
	Long	Low	- 0.54				
		High	- 0.35				
LGV	- 0.34						
HGV	- 0.33						
PM							
Car Business	Short	Low	- 0.10	-0.29	-0.23		
		High	- 0.07				
	Long	Low	- 0.21				
		High	- 0.08				
Car Other	Short	Low	- 0.42				
		High	- 0.39				
	Long	Low	- 0.47				
		High	- 0.44				
Car Commute	Short	Low	- 0.28				
		High	- 0.26				
	Long	Low	- 0.43				
		High	- 0.32				
LGV	- 0.32						
HGV	- 0.32						

A1.4.9 Freight Demand Elasticities

Increases in the cost of goods transport would be expected to have a substitution effect (change in the use of an input for a given level of output) as well as reducing the profit maximising scale of output, thereby reducing demand for all inputs.

The distinction between short and long run effects applies to freight transport as well as car transport. In the long run, firms or consumers are better able to adjust to changes in cost and therefore long run demand responses tend to be more elastic.

Oum et al (1990) find the 'most likely range' for road freight elasticity of -0.7 to -1.10 [should this be minus 1.10?]. These elasticities relate to the change in demand in response to a percentage change in total goods transport costs and are therefore not equivalent to toll or fuel price elasticities.

Cross mode elasticities for freight are very much dependent on the local context and the commodity. For example, the elasticity for valuable goods is likely to be low since minimising storage costs of these goods is more important than minimising transport costs. Low value goods transport will be less sensitive to price changes.

A range of response mechanisms are open to manufacturers or logistics firms in response to a rise in cost, such as fuel cost. Firms can respond to increases in costs by becoming more efficient. For instance, purchasing more fuel efficient vehicles, using more fuel efficient driving styles, optimising load factors (consolidating shipments, increasing the number of return loads or changing the volume and location of depots), reducing delivery frequency (thereby increasing inventory costs). Some of these mitigation measures are relevant to toll costs as well as fuel prices. There is less flexibility with respect to driving style for example, although more flexibility with respect to route choice and the ability to make round trips (to avoid a one way toll). These are likely to be short term responses.

Beyond efficiency measures, increased costs would be expected to reduce transport volumes by encouraging modal switch, or forcing firms to consider alternative (more local) suppliers. These could be considered to be a medium term response. In the longer term, firms may consider altering the volume of goods produced at a particular site or even shifting manufacturing locations. Efficiency measures will typically be instigated by the logistics operator whilst changes in the volume of goods transported will be instigated by the producer if and when higher costs are passed on from the haulier.

Finally, demand for freight transport could fall if higher production prices are passed on to the customer which results in a change in overall demand.

A1.4.10 Traffic Modelling – Technical Details

As stated in Section 1.2, the 2005 base year M4 SATURN traffic model was used to inform this study. In the original traffic model, the Severn tolls were applied as monetary penalties in 2005 prices, in conjunction with time penalties to reflect delays at the toll booths. The delay times were measured during journey time surveys in 2006, conducted for each of the time periods (AM, Inter Peak and PM peak hours).

For the purposes of this study, the original traffic model had the demand segmented further into the 14 user classes defined in Section 1.3. In addition to this, the toll penalties were converted from monetary values into time penalties based on WebTAG Values of time but with weightings applied to the demand segments according to the local SP data, as detailed in Section 1.3. The time penalties to reflect the delay at the toll booths were retained.

The elastic responses to changes in travel costs were undertaken using a 'power formulation' in SATURN, given as follows:

Equation (5)

$T=T^0 (C/C^0)^P$

Where T denotes the new number of trips between any given origin and destination pair, T^0 represents the number of trips between that origin and destination in the reference matrix, C represents the cost of travel on the road network and C^0 represents the travel cost between that origin and destination in the reference case. P is a user defined parameter (negative value) that determines the degree of elasticity.

The base year traffic model was used to undertake 'realism testing' as described in WebTAG Unit 3.10.4, where the model was calibrated to ensure that its responsiveness (elasticity) to changes in travel costs is realistic. P values were calculated to give a 3% overall reduction in vehicle kilometres for non-freight traffic in response to a 10% increase in fuel costs. The overall daily arc elasticity and elasticities for the individual user classes and time periods are shown in Table 5 above, and are broadly in line with the recommended elasticities given in WebTAG 3.10.4. The base year traffic model was used to produce scenario projections for 2018, 2023 and 2028 using traffic growth factors taken from the TEMPRO v6.2 database. Similarly, 2010 scenarios were also modelled by applying the TEMPRO forecasts to the 2005 base year.

Appendix B

Econometric Analysis

B1 Econometric Analysis

B1.1 The development of the econometric model

The model used in the investigation of the impact of peripherality/accessibility on productivity in Wales (Boddy et al 2008) is adapted to allow estimates to be made of the economic impact of various toll regimes. In that study, the two spatial variables were as follows:

Accessibility provides a measure derived from travel time to cities and towns within a defined range of any location. It represents a more locally focused measure emphasising accessibility to centres of population, employment and economic activity within a maximum of two hours' drive-time from any given location. Five time zones were constructed around each city (from 0-0.25 hours up to 1.5-2 hours) and two time zones around each town (<0.5 hours, 0.5-1.0 hours) based on network distance and average travel times on different classes of road. These were then combined to generate a single score, standardised to a scale of 1-10 for each location. Average values were then derived at the level of unitary authorities / districts.

Peripherality uses a gravity-model formulation based on the inverse of travel distance between places by road and a measure of the potential of interaction between places based on economic mass in terms of population size. This index was built up at unitary authority/district-level across the whole of Wales and England. It provides a broad-based index measuring what is commonly called economic mass or economic potential. It incorporates information on the size and location relative to all other places in Wales and England.

The 2008 study found the following:

- The effect of accessibility on labour productivity was positive, but part of this can be explained by the plant's characteristics and the sector in which it operates.
- Plants across the accessibility continuum may well decide to alter their choice of techniques (such as their ratio of labour to capital) in order to offset the detrimental effect typically associated with poor accessibility.
- The effect of peripherality on labour productivity was negative and this can also be partly explained by firm level characteristics.
- However, in Wales, as opposed to England and Wales as a whole, there was little significant residual influence of peripherality on productivity once industrial structure is taken into account.
- In the re-estimation of the 2008 model, two spatial variables were used: peripherality, defined as above, which is similar to the spatial variables used in the agglomeration literature discussed. Accessibility was defined in terms proximity to the M4/M5 interchange.
- In deriving accessibility and peripherality, three basic vehicle types were considered[48] reflecting the Severn Crossings toll structure. Generalised costs of travel were calculated by the method described in Section 5, which

[48] Cars, Light Goods Vehicles and Heavy Goods Vehicles

combines toll costs with fuel costs and the cost of lost time (including toll delay). An overall average cost was calculated weighted by the traffic volumes of the three vehicle types.

- Estimates of the influence of peripherality on productivity for England and Wales were undertaken using the latest available data. While this data was accessed through a different service to that used in the 2008 UWE study, it was possible to reproduce results for 2004 (the data used in the 2008 study) with minor differences. Estimates of the influence of peripherality for more recent years were made for England and Wales, Wales alone and South East Wales using a peripherality index calculated at both unitary authority and NUTS 3 levels. Some sufficiently significant and consistent results were obtained to allow calculations of toll impact to be made. The estimations of accessibility to the M4/M5 interchange were used as a target destination for firms in SE Wales.

No significant results were obtained for accessibility in the sense that we could not be confident that the observed association with productivity had not occurred by chance. Compared with the previous UWE study, we are using accessibility to the M4/M5 interchange rather than accessibility to local economic mass. We are thus omitting the important local accessibility to economic mass represented by Swansea, Cardiff and Newport. These are picked up by the peripherality variable which accounts for the greater significance of this variable compared with the previous study. It also indicates that local spatial effects are likely to be more important in SE Wales than in Wales as a whole and England and Wales together.

B1.2 Sample Issues

Table B1.1 Firm size by Year

	Size of Workforce					
Year (Sample Size)	**<21**	**21-50**	**51-75**	**76-100**	**101-200**	**>200**
2004 (4,041)	1,189 (29.4)	1,708 (42.3)	403 (10.0)	189 (4.7)	262 (6.5)	290 (7.2)
2005 (3,840)	1,123 (29.2)	1,627 (42.4)	382 (10.0)	165 (4.3)	261 (6.8)	282 (7.3)
2006 (1,475)	707 (47.9)	218 (14.8)	120 (8.1)	62 (4.2)	134 (9.1)	234 (15.9)
2007 (1,666)	821 (49.3)	256 (15.4)	117 (7.0)	70 (4.2)	145 (8.7)	257 (15.4)

Source: ARD2

Following an in-depth investigation of different data sources (Annual Respondents Database (ARD) panel and various ARD2 data files) it was established that there were 9,758 Welsh firms with information on capital stock, and employment for 2006 but no information on productivity. Productivity data is available only through the ARD2 restricted data sample hence we are restricted to using ARD2 only for the productivity model.

There was the additional problem too that capital stock data was not available for 2007 and had to be imputed based on the previous year's data. Merging information on businesses for 2006 and 2007 restricts the sample to those

businesses with some record of capital stock in 2006[49]. This will mean a further reduction in our working sample between 2006 and 2007.

Samples for all years were reduced significantly when merging the ARD2 and Capital Stock data. This is explained largely by 90-95 per cent of capital stock data missing from the data set for years 2004-2006. Missing capital stock data for firms' in 2006 can be calculated from information on firms' capital stock in 2005. However only the ARD2 contains the productivity data so more observations for capital would not be matched by more observations for productivity. Unfortunately, at the time of writing this report the 2008 ARD2 dataset is not in a workable form so cannot be used in this study.[50]

Conventional data cleaning resulted in the removal of firms with productivity less than zero or missing and employment either less than zero or unrecorded. Tables B2.2 and B2.3 show the working sample sizes by industry for Wales and England respectively. In both tables production and other services dominate the samples.

Table B1.2 Working sample size for Wales

	2004	2005	2006	2007
Construction	85	85	24	<10
Catering	69	71	18	10
Motor Trade	38	40	16	10
Production	408	370	237	206
Property	23	22	14	10
Retail Trade	48	44	34	12
Other Services	522	541	125	101
Wholesale	51	53	24	25
Total	1,244	1,226	492	N/A

Source: ARD2 and Capital Stock Dataset

Note: Due to the sensitive nature of the data any cells less than 10 need to be censored. This explains the <10 figure for Construction in 2007 and the 'Total' number not being disclosed for 2007

[49] Capital stock comprises 3 categories: plant and machinery, buildings and vehicles. The depreciation rates are respectively 6%, 2% and 20%. The formula we used is taken from Gilhooly (2008), $Firm\,CapitalStock_{2007} = \{Firm\,Capital\ Stock_{2006} * (1 - depreciation)\} + Real\ Net\ Capital\ Expendture_{2007}$

[50] Of the 8 ARD2 files the first file for the catering industry is in standard ARD2 form. However the remaining 7 industry files are not. Furthermore none of the variables are defined. Throughout this process it required a huge amount of investigations and cross-referencing t make sure the correct variables were being used. This problem can be overcome by simply producing a meta file (that usually accompanies any cross sectional, panel or time-series data series) that defines the variable and critically what the values observed mean. Some variables have concentrated values around 0,1 or 2. This would indicate that the numbers represents ordered responses, e.g. 'yes',' no' or 'maybe'. This report flagged up the problem and the ONS has been informed. The advice from ONS is not to use the 2008 ARD.

Table B1.3 Working sample size for England

	2004	2005	2006	2007
Construction	261	348	354	140
Catering	407	546	400	214
Motor Trade	186	248	218	107
Production	3,097	3,036	2,730	2,182
Property	143	158	149	118
Retail Trade	450	529	548	294
Other Services	2,676	3,196	2,538	1,723
Wholesale	674	694	633	425
Total	7,894	8,755	7,570	5,203

Source: ARD2 and Capital Stock Dataset

B1.3 Model further details

The larger the size of β or (1-β) the greater the impact changes in L or K will have on output. The coefficients here represent partial elasticities. If β was equal to 0.2 then we would say a 1 per cent increase in labour input would increase productivity by 0.2 per cent. It is not necessarily the case that simply increasing K or L will have a positive or even a constant impact on output. It may be that as inputs increase in number that inefficiencies arise in the production process resulting in diminishing returns to one or both inputs[51].

The variables of interest to this study capture accessibility and peripherality of firms to the Severn Bridge. The six variables defined in Table A2.4 were created for NUTS3 areas. Because of missing data it was not possible to calculate PGVADist or PGVATime for Unitary Authority areas. The variables ranged in value from 0-1, with higher values indicating greater distance (in miles and time) from economic cluster/mass.

Table B1.4 Peripherality Variables

Variable Name	Definition
PGVADist	Peripherality to economic cluster (gross value added) by distance.
PGVATime	Peripherality to economic cluster (gross value added) by time.
PTPOPDist	Peripherality to economic cluster (total population) by distance.
PTPOPTime	Peripherality to economic cluster (total population) by time.
PWPOPDist	Peripherality to economic cluster (working population) by distance.
PWPOPTime	Peripherality to economic cluster (working population) by time.

It can be seen in Tables A2.5 and A2.6 that the peripherality terms are highly correlated whether calculated at NUTS3 or Unitary Authority.

[51] For example employing more workers in a small factory may cause over-crowding that reduces the size of the extra output and may even cause labour productivity to drop below zero.

Table B1.5 Correlations between Peripherality (NUTS3)

	PGVADist	PGVATime	PTPOPDist	PTPOPTime	PWPOPDist	PWPOPTime
PGVADist	1					
PGVATime	0.9999	1				
PTPOPDist	0.7148	0.7134	1			
PTPOPTime	0.7158	0.715	0.9995	1		
PWPOPDist	0.7387	0.7372	0.9988	0.9983	1	
PWPOPTime	0.7398	0.7389	0.9984	0.9988	0.9995	1

Number of NUTS3 areas being 104.

Table B1.6 Correlations between Peripherality (Unitary Authority)

	PTPOPDist	PTPOPTime	PWPOPDist	PWPOPTime
PTPOPDist	1			
PTPOPTime	0.9996	1		
PWPOPDist	0.9981	0.9972	1	
PWPOPTime	0.9982	0.9981	0.9996	1

Number of Unitary Authority areas being 346.

B1.4 Determinants of productivity differentials

We used each of peripherality terms separately for years 2004, 2005, 2006 and 2007. Presented in Table A2.7 are results for NUTS3 areas in Wales, South-East Wales and England & Wales using PGVADist as the peripherality term. Proximity to gross value added area, rather than proximity to total population or working population produces more robust (statistically significant) results for peripherality. Proximity to gross value added economic mass means benefitting from far more spill-over effects (e.g. exposure to new technology, human capital, more capital expenditure and more knowledge) than being close to large populations and working populations where any spill-over would be expected to be less.

Columns 1-4 run the regression for Wales only for the four years and we observe the coefficient is between 0.02-0.03 but that this is only statistically significant in 2004 and 2005. A coefficient of 0.03 means that if a firm located in Wales moves 1 unit further away from the economic mass that productivity will decline by 0.03 per cent. Columns 5-8 use English and Welsh firms only and control for Wales by interacting all of the variables in the standard model with Wales. The coefficient on peripherality is negative and significant but the size of the coefficient is reduced markedly for all four years. When looking at South-East Wales only the peripherality term is the expected sign but only significant for 2004 and 2007.

Overall the table indicates that peripherality has a small impact on productivity. This impact is not robust over time. This is likely caused by the sampling issues mentioned previously.

The remaining variables in the model are quite robust over time with coefficient size varying by year but given the change in sample make-up this is to be expected. Generally firms located in Wales or South-East Wales do not use capital as efficiently as firms located in England. Results in columns 5-8 mean that a 1 per cent increase in capital by companies in Wales will produce on average 0.04-0.07 per cent less productivity growth compared to companies in England. Increasing capital stock in Wales does positively affect productivity but not by as much as in England.

Columns 5-8 also illustrate that over-manning in Wales is more of an issue than in England. For Wales a 1 per cent increase in labour results in a 0.063 per cent decline in worker productivity compared to English firms based on 2005 results. These results vary by year, meaning a robust estimate for the time period is problematic.

As previously reported to the Welsh Government, firms with larger number of plants are significantly more productive and that this is particularly the case for Welsh firms. A 1 per cent increase in the number of units a Welsh firm has will increase productivity per worker by 0.1 per cent in 2004, 2005 and 2007. This is likely due to spill-over effects such as the sharing of knowledge, information, management practices etc. There are no robust differences between Welsh and English firms by industrial sector.

Table B1.7 Production Function Results for NUTS3 areas 2004-2007

	Wales				Wales & England				South-East Wales			
	2004	2005	2006	2007	2004	2005	2006	2007	2004	2005	2006	2007
Dependent Variable: Gross Value Added per worker (Log)												
	1	2	3	4	5	6	7	8	9	10	11	12
Peripherality distance from gross value added economic mass	**-0.034** (0.015)**	**-0.029** (0.014)**	**-0.019 (0.025)**	**-0.002 (0.014)**	-0.006*** (0.000)	**-0.008*** (0.000)**	**-0.007*** (0.000)**	**-0.007*** (0.000)**	**-0.033* (0.019)**	**-0.028 (0.022)**	**-0.051 (0.042)**	**-0.086** (0.036)**
Capital per worker (Log)	0.216*** (0.016)	0.211*** (0.017)	0.227*** (0.034)	0.206*** (0.033)	0.258*** (0.007)	0.285*** (0.007)	0.261*** (0.08)	0.274*** (0.009)	0.198*** (0.020)	0.197*** (0.023)	0.204*** (0.045)	0.246*** (0.036)
Workers (Log)	-0.044** (0.021)	-0.062*** (0.020)	-0.033 (0.031)	-0.063 (0.039)	-0.015** (0.008)	0.004 (0.006)	-0.014* (0.007)	0.023** (0.011)	-0.065** (0.026)	-0.075** (0.027)	-0.002 (0.042)	-0.111** (0.046)
Number of Units (LOG)	0.107*** (0.029)	0.065** (0.031)	0.055 (0.046)	0.096** (0.044)	0.005 (0.009)	-0.028** (0.009)	0.015 (0.104)	-0.023** (0.011)	0.086** (0.035)	0.070* (0.042)	0.025 (0.065)	0.117** (0.051)
Catering	-0.964*** (0.088)	-1.032*** (0.095)	-0.887*** (0.198)	-1.007*** (0.260)	-0.919*** (0.054)	-0.984*** (0.053)	-1.049*** (0.054)	-0.746*** (0.075)	-1.101*** (0.114)	-1.020*** (0.132)	-1.109*** (0.277)	-0.801*** (0.263)
Construction	0.164* (0.098)	0.241** (0.103)	0.352 (0.225)	0.352 (0.261)	0.224*** (0.045)	0.343*** (0.044)	0.369*** (0.051)	0.460*** (0.062)	0.078 (0.127)	0.141 (0.146)	0.185 (0.307)	0.504* (0.281)
Motor-trade	0.153 (0.125)	-0.130 (0.132)	0.217 (0.240)	-0.557** (0.235)	0.2489*** (0.063)	0.095 (0.061)	0.090 (0.066)	0.178** (0.083)	0.184 (0.165)	-0.121 (0.184)	0.198 (0.371)	-0.625** (0.281)
Property	-0.631*** (0.162)	-0.433** (0.178)	-0.380 (0.257)	-0.692** (0.265)	-0.130* (0.072)	-0.123 (0.076)	0.048 (0.079)	0.085 (0.081)	-0.670*** (0.199)	-0.514** (0.231)	-0.378 (0.301)	-1.058*** (0.271)
Retail	-0.791*** (0.119)	-0.711*** (0.132)	-0.687*** (0.184)	-1.065*** (0.252)	-0.621*** (0.044)	-0.860*** (0.046)	-0.761*** (0.047)	-0.654*** (0.058)	-0.868*** (0.144)	-0.767*** (0.187)	-0.749*** (0.266)	-0.764** (0.298)
Other services	-0.375*** (0.054)	-0.296*** (0.058)	-0.216* (0.113)	-0.440*** (0.105)	-0.217*** (0.0232)	-0.151*** (0.025)	-0.265*** (0.027)	-0.330*** (0.029)	-0.387*** (0.070)	-0.343*** (0.081)	-0.212 (0.159)	-0.444*** (0.124)
Wholesale	-0.072 (0.109)	0.209* (0.115)	0.162 (0.195)	-0.064 (0.172)	0.259*** (0.036)	0.292*** (0.040)	0.228*** (0.041)	0.188*** (0.045)	-0.173 (0.139)	0.078 (0.158)	0.227 (0.267)	-0.221 (0.205)
Constant	6.088*** (1.459)	5.681*** (1.399)	4.521* (2.506)	3.230** (1.393)	3.189*** (0.062)	3.145*** (0.059)	3.233*** (0.066)	3.091*** (0.087)	6.254*** (1.854)	5.793*** (2.114)	7.589* (4.083)	11.532*** (3.574)
Wales * peripherality					**0.000 (0.002)**	**0.006*** (0.002)**	**0.002 (0.002)**	**0.002 (0.003)**				
Wales * Log Capital per worker					-0.040**	-0.072***	-0.033	-0.069**				

	Wales				Wales & England				South-East Wales			
	2004	2005	2006	2007	2004	2005	2006	2007	2004	2005	2006	2007
Dependent Variable: Gross Value Added per worker (Log)												
	1	2	3	4	5	6	7	8	9	10	11	12
					(0.020)	(0.022)	(0.036)	(0.035)				
Wales*Log Worker					-0.024 (0.025)	-0.063 ** (0.024)	-0.018 (0.033)	-0.087** (0.043)				
Wales*Log units					0.103*** (0.034)	0.099** (0.038)	0.042 (0.049)	0.117** (0.048)				
Wales*Catering					0.142 (0.166)	-0.178 (0.185)	0.092 (0.255)	0.139 (0.365)				
Wales*Construction					0.126 (0.170)	-0.235 (0.189)	-0.084 (0.279)	0.292 (0.367)				
Wales*Motor trade					0.079 (0.195)	-0.375* (0.214)	0.049 (0.290)	-0.344 (0.332)				
Wales*Production					0.175 (0.144)	-0.138 (0.164)	-0.073 (0.196)	0.402 (0.268)				
Wales*Property					-0.322 (0.228)	-0.448* (0.256)	-0.494 (0.308)	-0.374 (0.377)				
Wales*Other services					0.028 (0.137)	-0.274* (0.154)	-0.016 (0.185)	0.291 (0.261)				
Wales*Wholesale					-0.154 (0.177)	-0.223 (0.197)	-0.133 (0.254)	0.148 (0.304)				
No. of observations	1,256	1,243	497	387	9,252	10,216	8,114	5,608	742	713	288	236
F-statistic	45.36	38.500	10.210	10.360	148.58	173.690	120.060	85.410	27.10	18.70	5.720	9.990
R-squared	0.286	0.256	0.188	0.233	0.262	0.273	0.246	0.252	0.290	0.227	0.186	0.329

*Notes: ***,**,* indicates statistical significance at the 1,5 and 10 per cent level. The reference group in the model is production firms.*

Columns 1-4 and 9-12 consistently find that the catering, retail and other services sector have lower productivity levels relative to production in Wales and South-East Wales. This is also found for Wales and England. For Wales and England the construction sector workers are more productive than production workers. There is little evidence of industry level differences between English and Welsh firms.

In order to understand the relationship between peripherality and productivity further we tested whether there were any differences in the relationship by industry across different years as well as when we pool the years of data.

Table A2.8 indicates that peripherality has different impacts on different industries and that these tend to be consistent over time making the analysis worthwhile. While this table does not give samples sizes for the different sectors (these can be found in Table **1**), it is worthy of note that the production and other services sectors dominate the sample. Given this it is expected that a consistent story is found for these two sectors and this is confirmed in Table A2.8. Half of the coefficients below are significant at the 1 per cent level, with robust findings being reported for catering, production, other services and wholesale. The pooled results indicate that that a 1 point increase in peripherality will reduce productivity by 0.004% in catering and by 0.008% in wholesale.

Table B1.8 Peripherality Coefficients by Industry by NUTS3 area

	2004	2005	2006	2007	Pooled
Catering	-0.003***	-0.006***	-0.005***	-0.004**	-0.004***
Construction	-0.004**	0.003*	-0.006**	-0.007*	-0.002
Motor Trade	-0.012**	0.002	0.002	0.004	0.001
Production	-0.009***	-0.010***	-0.009***	-0.010***	-0.007***
Property	-0.000**	-0.004	-0.006*	-0.008***	-0.005**
Retail	0.000	-0.003**	-0.004**	-0.002**	-0.001
Other Services	-0.007***	-0.009***	-0.007***	-0.007***	-0.007***
Wholesale	-0.009***	-0.012***	-0.010***	-0.010***	-0.008***

Appendix C

Business Survey

C1 Business Survey

C1.1 Sample

The sample for the business survey was as follows:

- A total of 451 businesses of which 351 were based in South Wales and 100 were based in South West England.
- The sample consisted of 146 firms which were considered to be within the transportation and storage sector. The remaining 305 firms have been labelled 'general business' in order to distinguish between these two groups.

C1.2 Results

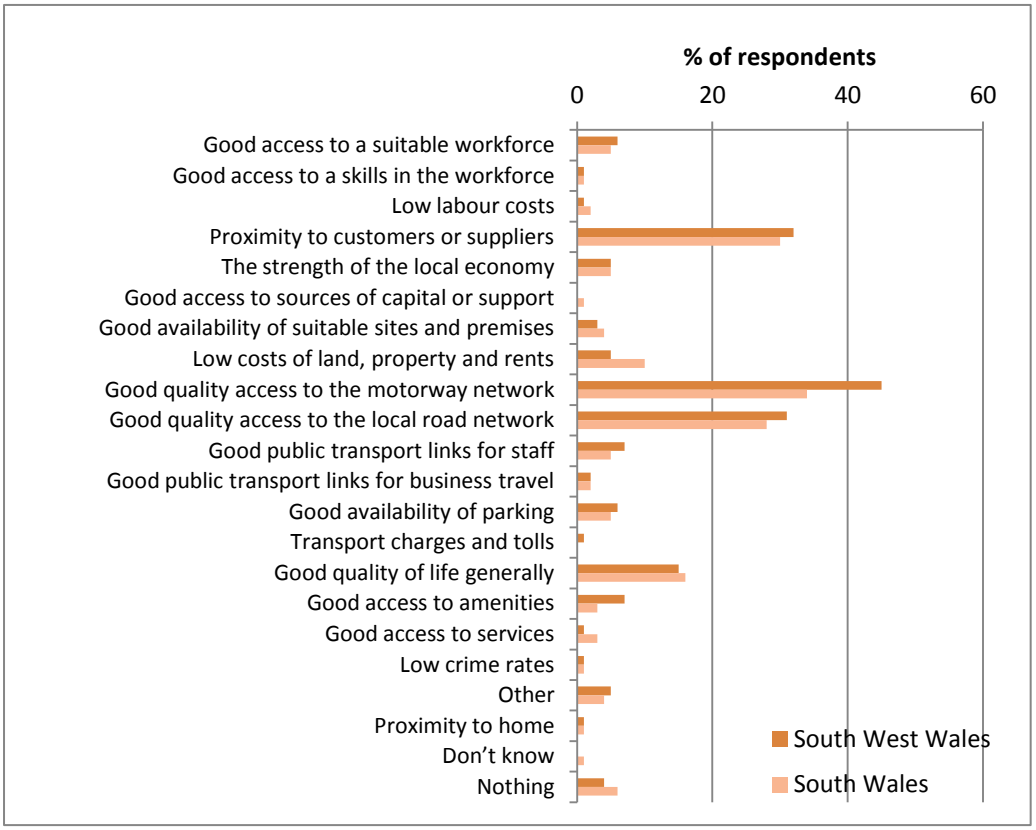
It should be noted that the questionnaire for the 146 transportation and storage firms differed from the 305 general businesses in order to ensure that the questions provided a better fit with the activities of these two groups. In the following sections it is made clear who has responded to each question. Results have also been split into responses from Welsh firms and responses from firm based in the South West of England. Results have also been displayed graphically separated into general business and transportation and storage firms where applicable.

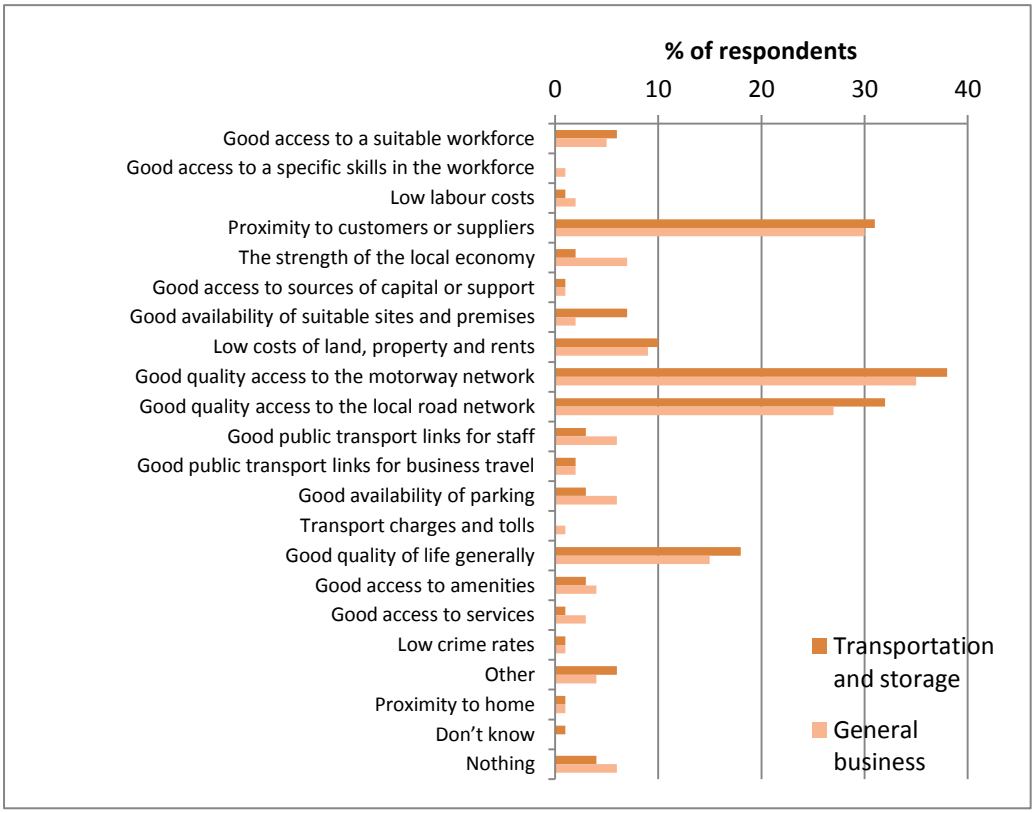
C1.3 Business Environment

'What are the main advantages of your current location?'

Businesses were asked to provide up to three responses to this question and the results can be seen below in Figure C1.1.

Figure C1.1 –Main advantages of current business location
Sample – All firms



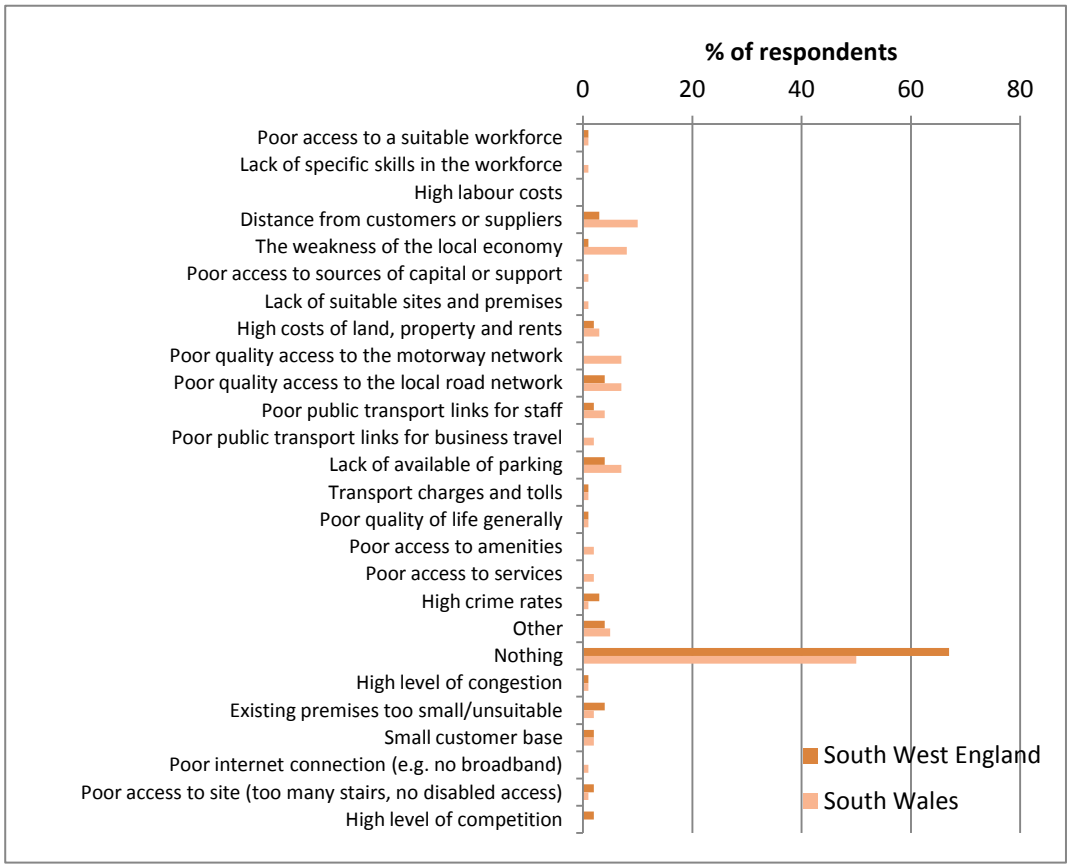


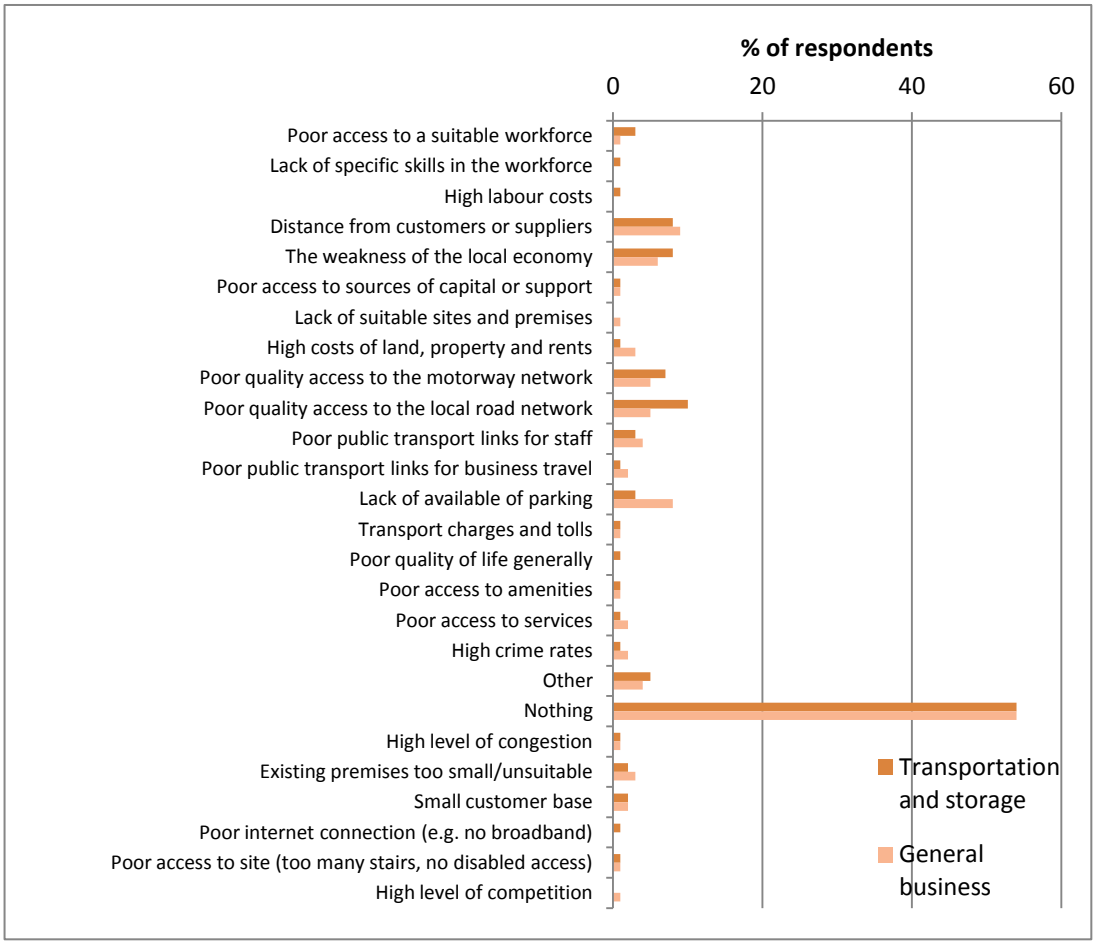
- It can be seen from Figure C1.1 that the most common responses about the main advantage relate to the quality of access to the road network (both motorway network and local road network) and proximity to customers or suppliers

'What are the main disadvantages of your current location?'

Businesses were permitted to give up to three disadvantages.

Figure C1.2 – Main disadvantages of current business location
Sample – All firms

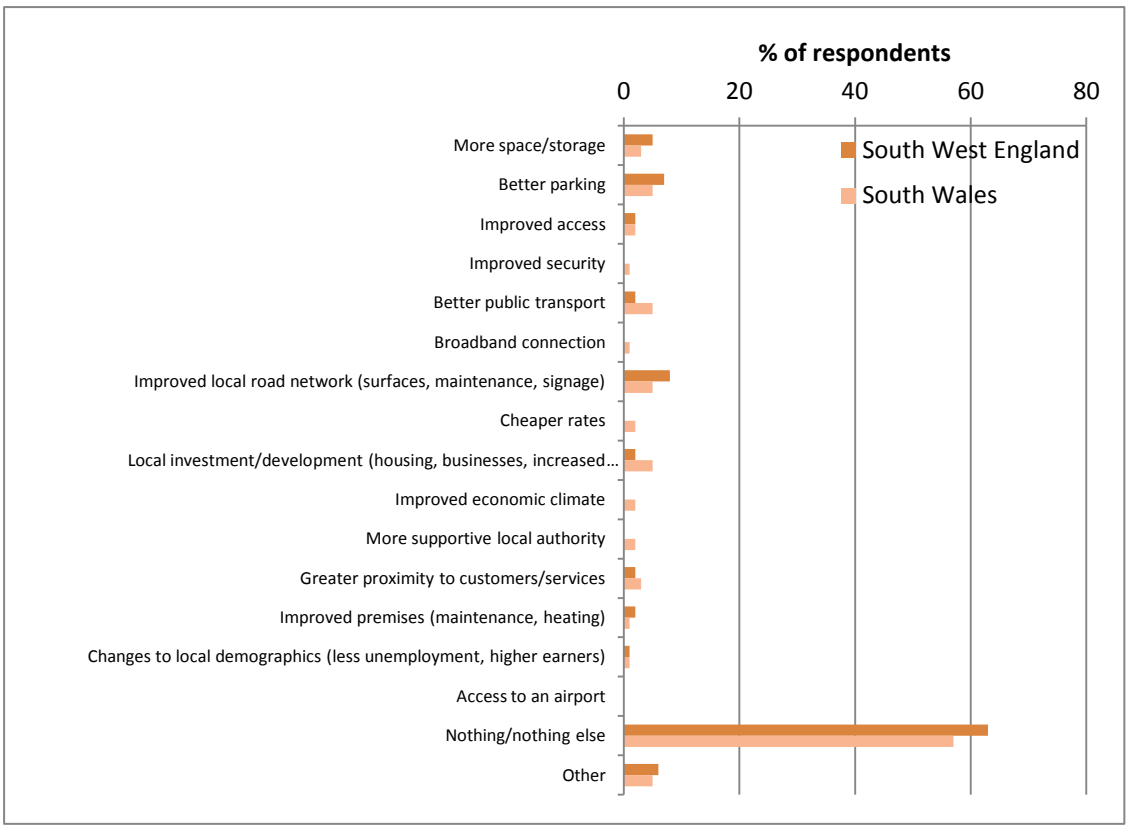


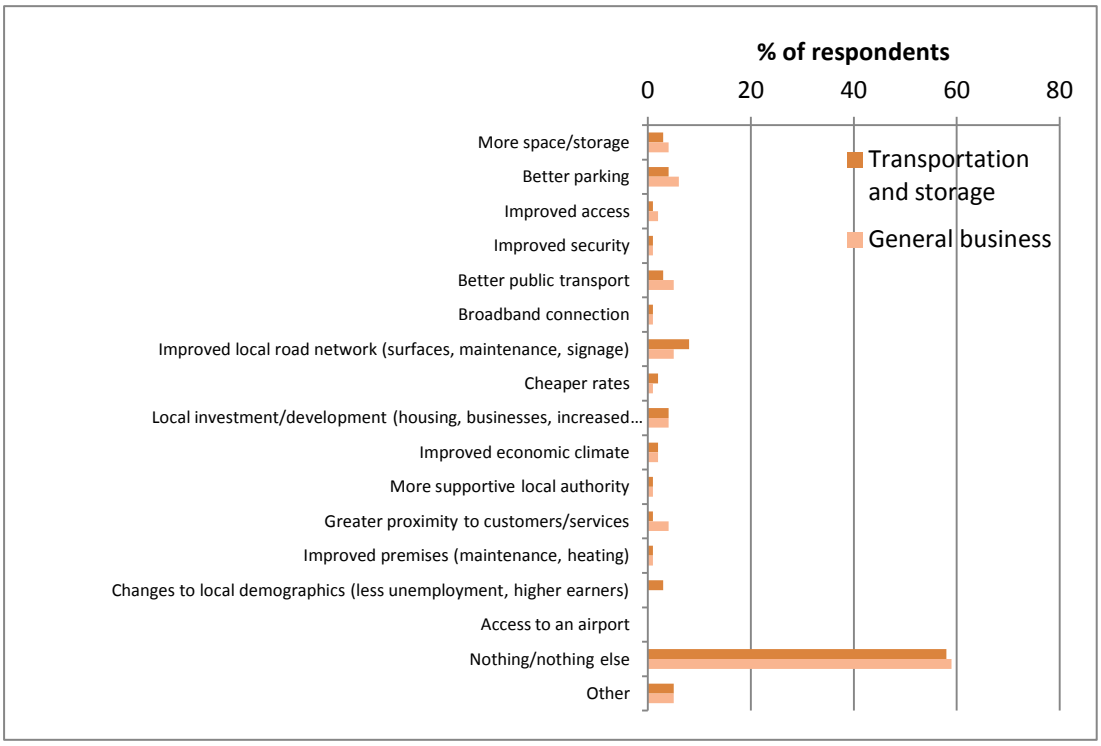


- While the by far the most common main location disadvantage response was 'nothing', three of the five categories which had numerous responses were poor quality of the local road network, the poor quality of the motorway network and the distance from customers or suppliers (with the other two being the lack of available parking and the weakness of the local economy)

'What factors would most improve the quality of your current location?'

Figure C1.3 –Factors that would most improve the quality of current business locations
Sample – All firms

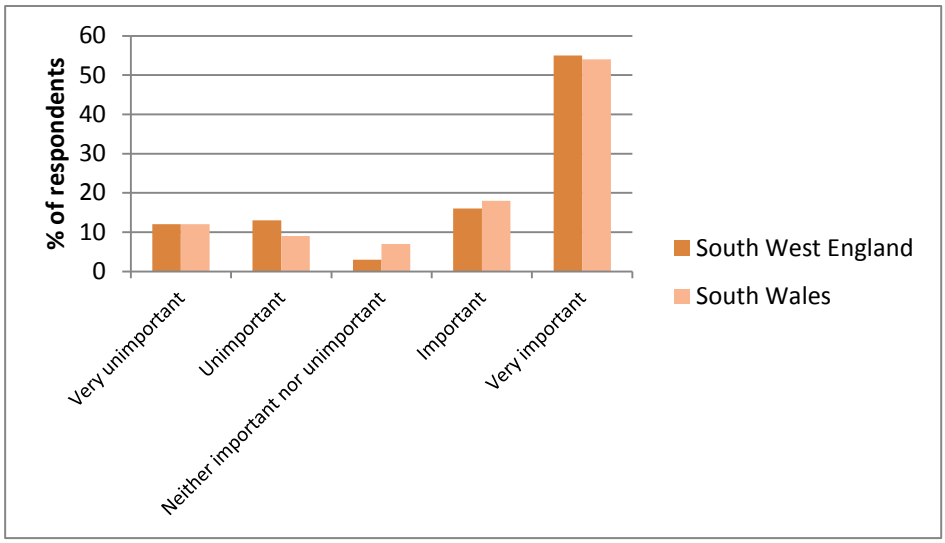




- While the most common response was that nothing else would improve the quality of current business location, the most frequent other responses related to transport – in particular, improved local road network and better parking.
- It is worth noting that within the 'other' category two firms specifically mentioned the removal of the Severn Crossings Toll

'***How important is the transport of goods to or from your establishment?'***

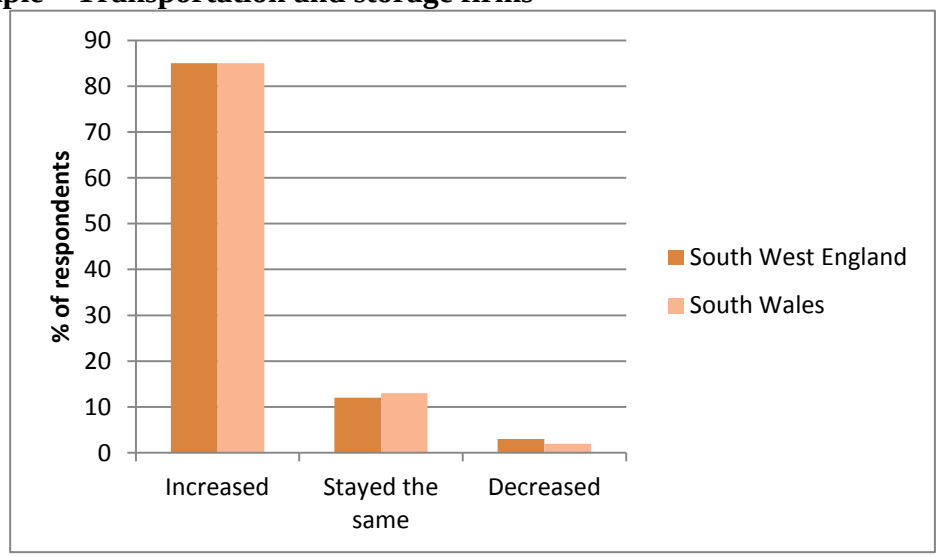
Figure C1.4 - Importance of transport of goods and materials to firms
Sample – General business



- The degree to which transport of goods and materials is important to general business firms is very similar in South Wales and the South West of England with 72% considering it either important or very important in both areas

'***Thinking about the last five years, in relation to other business costs, have your transport costs increased, decreased or stayed the same?'***

Figure C1.5– Change in transport costs relative to other transport costs over last 5 years
Sample – Transportation and storage firms



- The above graph shows that 85% (the same proportion in both the South West of England and South Wales) reported that transport costs had increased relative to other costs

Percentage of goods / customers by area of origin/destination

Transport firms were asked questions regarding the origins of goods movements. General business were asked questions regarding the locations of customers. The tables below display the findings of these questions with key points summarised underneath.

Table C1.1 – Approximate percentage of goods originating from different areas
Sample - Transportation and storage firms
South Wales

	The local area (10 mile radius)	South Wales	Rest of Wales	South West England	South East England and London	Midlands/North of England/ Scotland	Outside the United Kingdom
0%	25	50	82	73	73	73	88
1 to 9%	4	3	4	7	6	4	1
10 to 24%	12	23	12	12	14	12	3
24 to 49%	3	5	1	4	4	3	4
50 to 74%	11	9	1	2	2	4	2
75 to 100%	47	11	0	2	0	4	4

South West England

	The local area (10 mile radius)	South Wales	Rest of Wales	South West England	South East England and London	Midland/North of England/ Scotland	Outside the United Kingdom
0%	24	85	88	45	70	64	76
1 to 9%	3	6	3	3	??	3	3
10 to 24%	12	6	9	30	12	18	3
24 to 49%	3	3	0	6	12	12	3
50 to 74%	15	0	0	9	6	3	6
75 to 100%	42	0	0	6	0	0	9

- Table C1.1 shows that the highest proportion of goods originate from the local area. The pattern is similar for firms from South Wales and firms from the South West of England with 58% of Welsh firms responding 50% or more of goods originate from the local area compared to 57% of South West responses.

Table C1.2 – Approximate percentage of customers drawn from different areas
Sample – General Business
South Wales

	The local area (10 mile radius)	South Wales	Rest of Wales	South West England	South East England and London	Midlands/North of England/ Scotland	Outside the United Kingdom
0%	17	25	71	68	71	75	89
1 to 9%	4	8	9	10	10	11	3
10 to 24%	13	25	15	16	12	11	3
24 to 49%	9	17	4	5	3	2	2
50 to 74%	19	14	1	1	2	0	1
75 to 100%	38	11	0	0	3	1	2

South West England

	The local area (10 mile radius)	South Wales	Rest of Wales	South West England	South East England and London	Midlands/North of England/ Scotland	Outside the United Kingdom
0%	25	50	82	73	73	73	88
1 to 9%	4	3	4	7	6	4	1
10 to 24%	12	23	12	12	14	12	3
24 to 49%	3	5	1	4	4	3	4
50 to 74%	11	9	1	2	2	4	2
75 to 100%	47	11	0	2	0	4	4

The tables show that businesses in the South West of England tend to have a higher proportion of customers drawn from the local area.

Does your business transport its own goods or use haulage companies?'

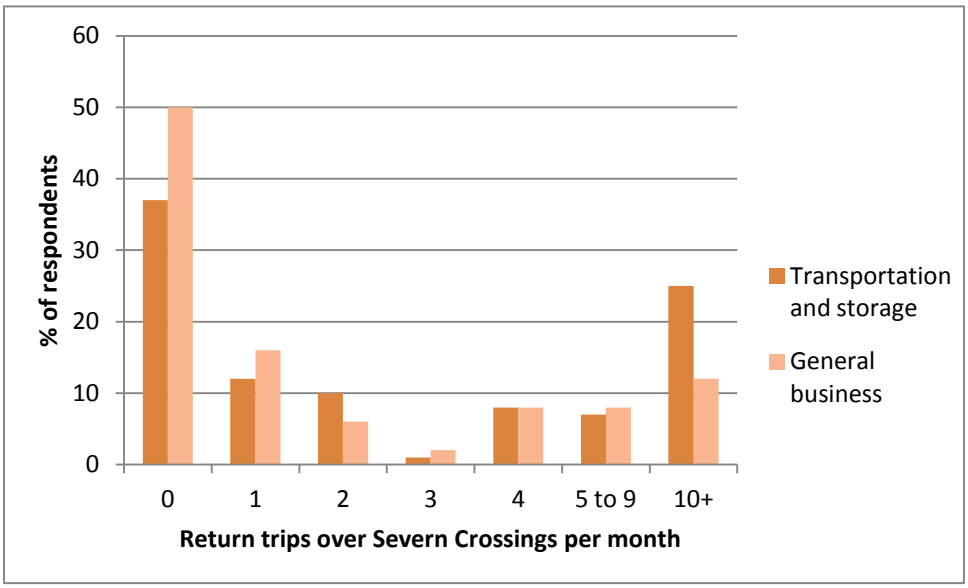
Figure C1.6 – Use of haulage companies to transport goods
Sample – General Business

The most common response was that the business transports all of its own goods with 44% of responses (38% South West of England and 46% South Wales)

C1.4 Use of the Severn Crossings

'In total approximately how many return trips are taken across the Severn Crossings in an average month?'

Figure C1.7 – Approximate number of return trips taken across the Severn Crossings in an average month
Sample – All firms

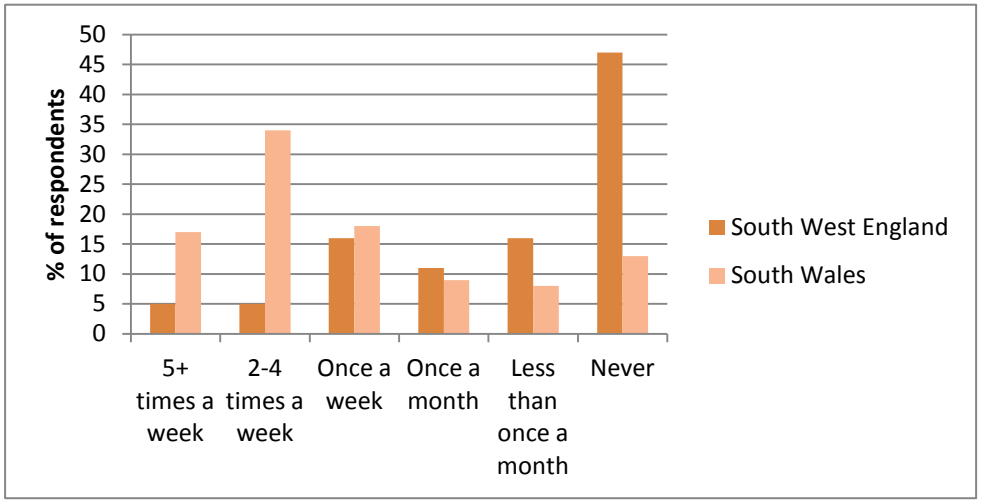


- The above figure shows that a higher proportion of Welsh firms use the Severn Crossings than South West of England firms and a higher proportion of transportation firms use the Crossings than general business firms.

'Approximately how frequently do you use the Severn Crossings to receive goods or raw materials from suppliers?'

Figure C1.8 - Approximate frequency of use of the Severn Crossings to receive goods or raw materials from suppliers

Sample – General business who answered transport of goods is either important or very important

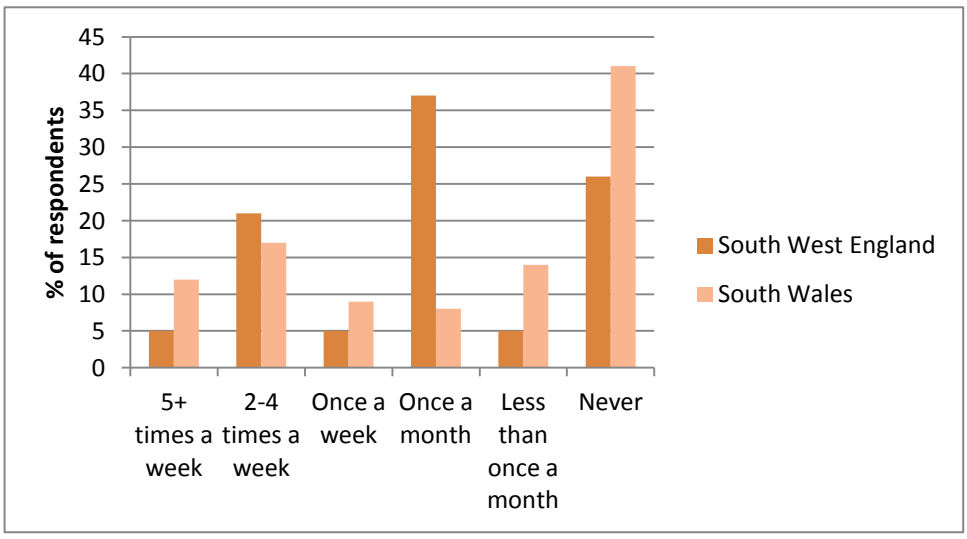


- The above figure shows a noticeable discrepancy in the proportion of firms who never receive goods or raw materials via the Severn Crossings with 47% of South West of England firms responding 'never' while only 13% of firms from South Wales responded 'never'.

'***Approximately how frequently do you use the Severn Crossings for transporting goods to customers?'***

Figure C1.9 - Approximate frequency of using Severn Crossings to transport goods to customers

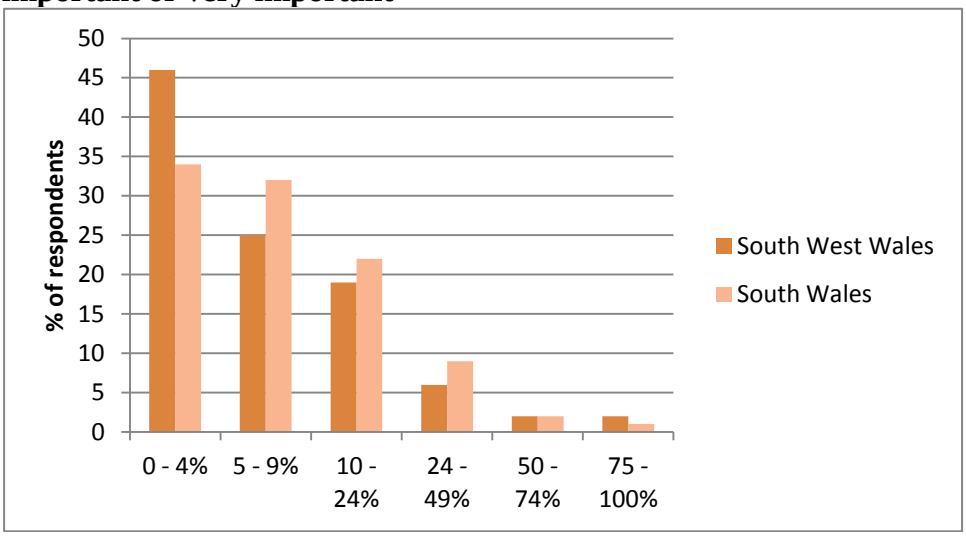
Sample – General business who answered transport of goods is either important or very important



- It is notable that more firms from South Wales responded they 'never' use the Severn Crossings to transport goods to customers than South West of England firms (41% compared to 26%)

'Approximately what proportion of total business costs for your business relate to the transport of goods/materials?'

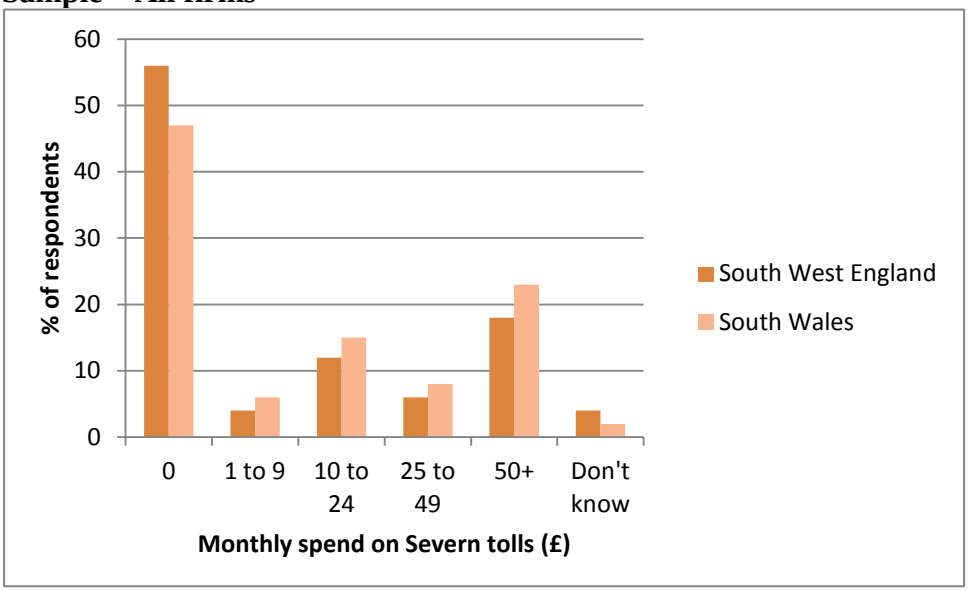
Figure C1.10 - Proportion of total business costs spent on transport Sample – General business who answered transport of goods is either important or very important

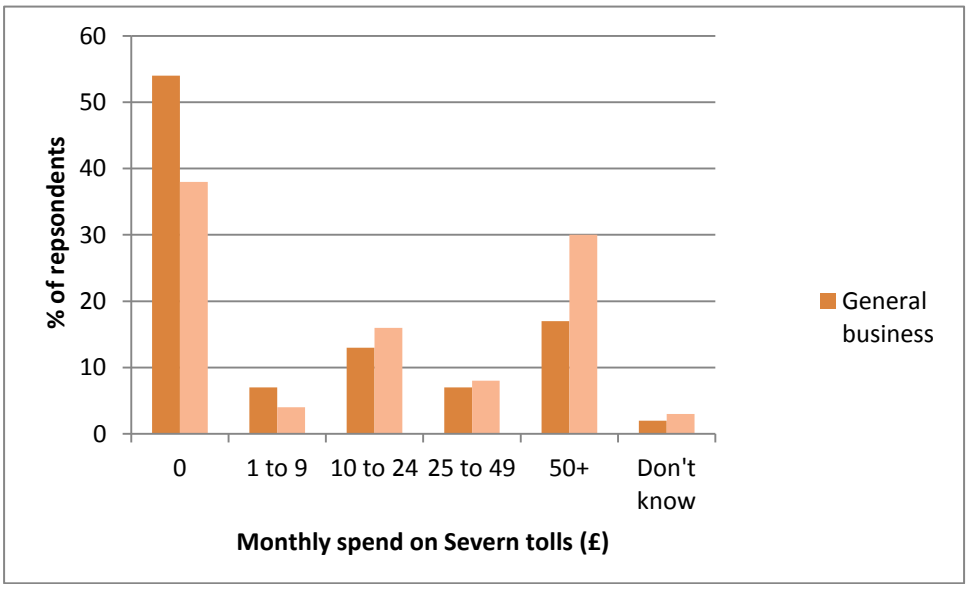


- The majority of respondents reported that transport cost are less than 25% of total business costs with these categories accounting for 89% of respondents

'Approximately how much per month does the business spend on toll payments?' amalgamated in Figure C1.11 below.

Figure C1.11 - Approximate monthly spend by business on toll payments Sample – All firms





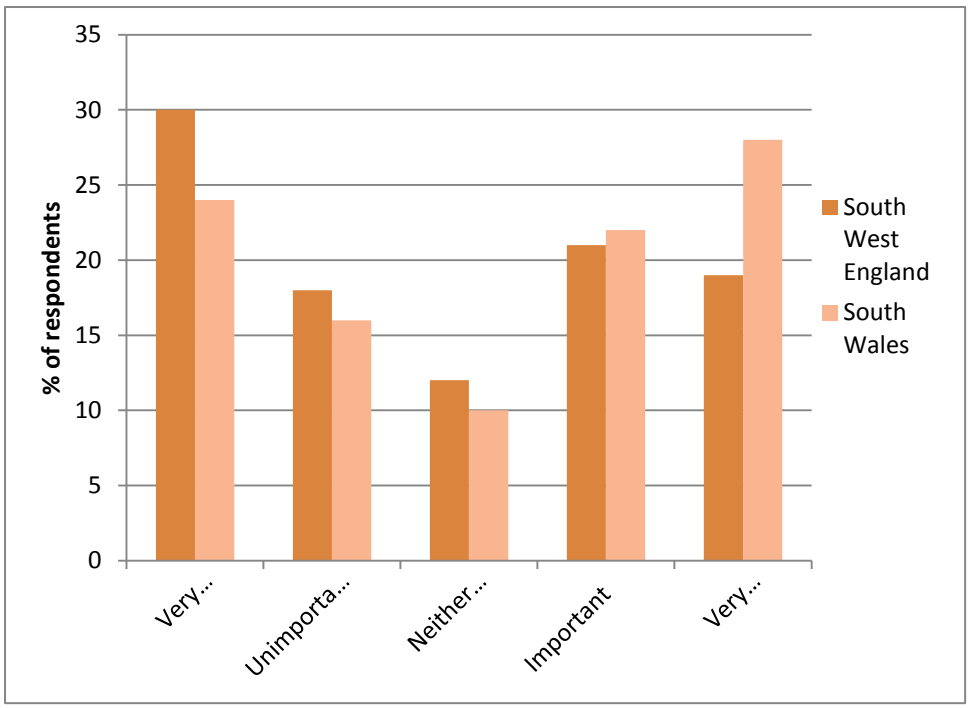
- £50 or more monthly spend on tolls category was higher for transport than general business – 30% compared to 17%

C1.5 Importance of Severn Tolls

'How important are the Severn Crossings for your business?'

The results are summarised below in Figure C1.12. Key points are also summarised below.

Figure C1.12 – Importance of Severn Crossings for Business



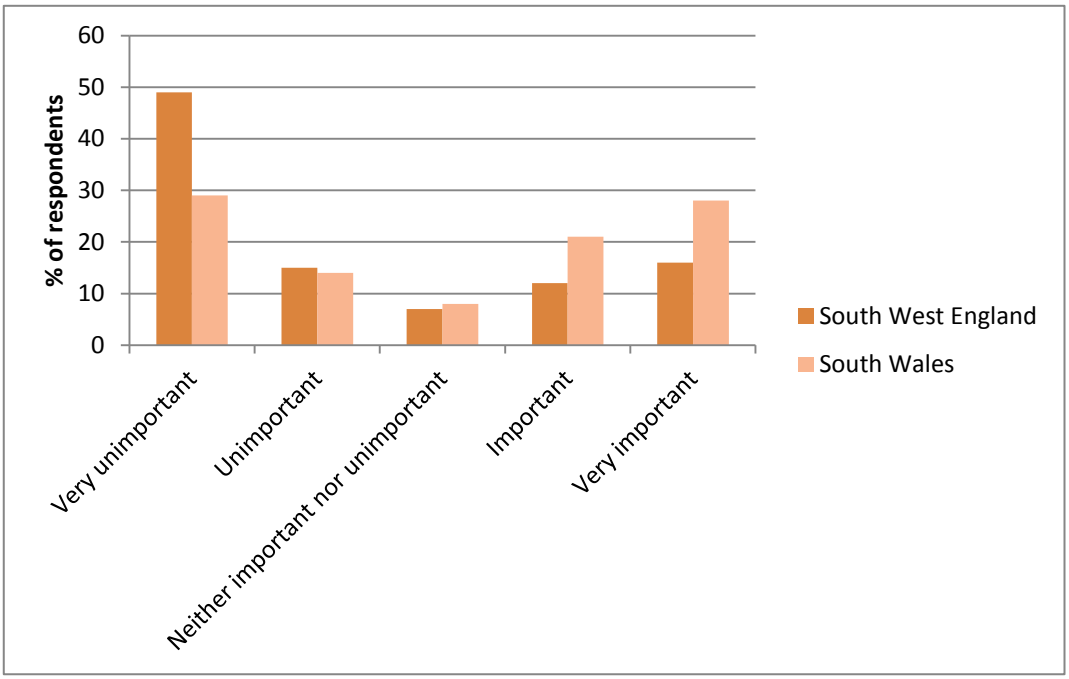
- The above figure shows that 50% of firms from South Wales consider the Severn Crossings either important or very important to their business compared to 40% for firms from South West England

'Thinking about movement of goods or supplies, how important are the Severn Crossings for your business?'

Figure C1.14 shows the results for this question.

Figure C1.14 - Importance of Severn Crossings for movement of goods or supplies

Sample – General Business



- The above figure shows that 50% of South West of England firms considered the Severn Crossings very unimportant for the movement of goods or supplies compared to 29% for firms located in South Wales

Appendix D

Consumer Survey

D1 Consumer Survey

D1.1 Sample

A total of 614 individuals were surveyed using a combined telephone and web survey. Respondents came from across the South West and the sample sought to be representative of the geography, age and gender of the region.

D1.2 Results

The results of the consumer survey are shown below.

Q1 - In the last twelve months have you made any shopping, leisure or holiday trips to Wales by car? If yes, please indicate how many for each purpose?

Q1a

		No.	%
Been to Wales by car in the last year	Total	614	100%
	Yes	227	37%
	No	387	63%

Q1b

		No.	%
Shopping	Total	614	100%
	0	545	89%
	1	37	6%
	2	14	2%
	3+	18	3%
Leisure (day trip)	Total	614	100%
	0	517	84%
	1	53	9%
	2	16	3%
	3+	28	5%
Leisure (1 or more nights)	Total	614	100%
	0	521	85%
	1	64	10%
	2	17	3%
	3+	12	2%
Holiday	Total	614	100%
	0	544	89%
	1	48	8%
	2	11	2%
	3+	11	2%
Visiting friends/relatives (day trip)	Total	614	100%
	0	556	91%
	1	28	5%
	2	11	2%
	3+	19	3%

Q1b

		No.	%
Visiting friends/relatives (1 or more nights)	Total	614	100%
	0	543	88%
	1	36	6%
	2	15	2%
	3+	20	3%

Q2 - In the next twelve months do you expect to make any shopping, leisure or holiday trips to Wales by car? If yes, please indicate how many for each purpose?

Q2a

		No.	%
Plan to go to Wales by car in the next year	Total	614	100%
	Yes	274	45%
	No	340	55%

Q2b

		No.	%
Shopping	Total	614	100%
	0	514	84%
	1	65	11%
	2	17	3%
	3+	18	3%
Leisure (day trip)	Total	614	100%
	0	483	79%
	1	83	14%
	2	26	4%
	3+	22	4%
Leisure (1 or more nights)	Total	614	100%
	0	504	82%
	1	78	13%
	2	19	3%
	3+	13	2%
Holiday	Total	614	100%
	0	515	84%
	1	76	12%
	2	12	2%
	3+	11	2%
Visiting friends/relatives (day trip)	Total	614	100%
	0	536	87%
	1	37	6%
	2	19	3%
	3+	22	4%
Visiting friends/relatives (1 or more nights)	Total	614	100%
	0	530	86%
	1	43	7%
	2	20	3%
	3+	21	3%

Q3 - What is the main reason for you not making any shopping, leisure or holiday trips to Wales by car?

		No.	%
Main reason for not making any shopping, leisure or holidays trips to Wales by car.	Total	385	100%
	Don't drive	34	9%
	No car / road transport	21	5%
	No interest in going to Wales	183	48%
	Wales is too far away	69	18%
	The Severn Bridge Toll	12	3%
	Prefer another method of transport (i.e. train)	16	4%
	Other	50	13%

Q4 - Were you aware that there are tolls for crossing the Severn Bridge?

		No.	%
Aware that there are tolls for crossing the Severn Bridge	Total	374	100%
	Yes	344	92%
	No	30	8%

Q5a - If there were no tolls on the Severn Bridge would it make any difference to the number of shopping, leisure or holiday trips to Wales you would make by car in the next twelve months?

		No.	%
Whether no tolls on the Severn Bridge would make a difference to the number of trips to Wales by car	Total	614	100%
	Yes, I would make more trips to Wales	150	24%
	No, it would make no difference	464	76%

Appendix E

Bibliography

Bibliography

Aecom, 2010. Humber Bridge Tolls Modelling and Appraisal Study. For the DfT. Aecom, York.

Armelius, H., & Hultkrantz, L., 2006. The politico-economic link between public transport and road pricing: An ex-ante study of the Stockholm road-pricing trial. *Transport Policy* 13 162–172

Boddy, M, Horswell, M, Plumridge, A and Webber, D, (2008) Peripherality in Wales, report for the Welsh Assembly Government, 2008.

Bottazi, G and Holm, J (2011), Workforce composition and the relationship between size, wages and productivity, Paper presented to the DIME conference, Maastricht, April 2011.

Cambridge Economic Consultants (1987) in Economic Effects of Road Infrastructure, DTZ Pieda.

Cameron, G. and Muelbauer, J., 1998. The Housing Market and Regional Commuting and Migration Choices, Scottish Journal of Political Economy.

Cleary, M.J. and Thomas, R.E., 1973. The economic consequences of the Severn Bridge and associated motorways, Bath University Press.

Colin Buchanan and Partners Ltd, 2008. Humber Bridge Tolls Impact Assessment: Final Report. For the East Riding of Yorkshire, Hull, North Lincolnshire and North East Lincolnshire Councils.

Colin Buchanan and Partners Ltd., 2009. Humber Bridge Impact Study: Phase 2 Report - Version 3. For the East Riding of Yorkshire, Hull, North Lincolnshire and North East Lincolnshire Councils.

Daunfeldt, S., Rudholm, N., & Rämme, U., 2008. Congestion charges and retail revenues: Results from the Stockholm road pricing trial. *Transportation Research Part A* 43 306–309 .

Debelle, G. and Vickery, J., 1999. Labour Market Adjustment: Evidence on Interstate Labour Mobility, Australian Economic Review (32(3), pp. 249-263).

Derek Halden Consultancy Ltd (DHC)., 2007. Evaluation of the Economic and Social Impacts of the Skye Bridge: Final Report. For Highlands and Islands Enterprise and HITRANS. DHC. Edinburgh, Scotland.

Dickerson, A, and McIntosh, S, (2011) An investigation into the relationship between productivity, earnings and age in the early years of a working life Report Prepared for the Low Pay Commission.

Duranton, G., and D. Puga. 2004. *Micro- foundations of urban agglomeration economies* in Handbook of regional and urban economics, vol. 4, ed. V. Henderson and J.- F. Thisse, 2063– 117. Amsterdam: North- Holland.

Eliasson, J., 2008. Lessons from the Stockholm congestion charging trial. *Transport Policy* 15 395–404

Faber Maunsell / Aecom, 2008. Humber Bridge Study: Final Report. For the Humber Bridge Board. Faber Maunsell, Altringham, Cheshire.

Forth Estuary Transport Authority (FETA), 2011. http://www.forthroadbridge.org

Fowkes, A.S, Johnson, D.H., Hyman, G., Fisher, D. and Ibanez, N., 2007. Results from the UK Department for Transport's 2006 M6 toll research project freight study.

Federation of Small Businesses (FSB), 2010. The Severn Bridge. Taking its toll on the economy? Aberystwyth University. For the Federation of Small Businesses.

Gifford, J.L. and Talkington, S.W., 1996. Demand Elasticity Under Time Varying Prices: Case Study of Day-of-Week Varying Tolls on the Golden Gate Bridge, Transportation Research Record (1558: 55-59).

Goodwin, P., Dargay, J. and Hanly, M., 2002. Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review, Transport Reviews: A Transnational Transdisciplinary Journal.

Gordon, I.R., 2000. Industrial Clusters: Complexes, Agglomeration and/or Social Networks?, Urban Studies (37(3), 513-532)

Graham, D.J. and Glaister, S., 2002. The Demand for Automobile Fuel: A Survey of Elasticities, Journal of Economics and Policy.

Graham, D, Investigating the link between productivity and agglomeration for UK industries, Centre for Transport Studies Imperial College London 2007.

Graham, D, Gibbons, S and Martin, R, The spatial decay of agglomeration economies: estimates for use in transport appraisal. Final Report, October 2010.

Harvey, G., 1994. Curbing Gridlock: Peak-Period Fees to Relieve Traffic Congestion, Transportation Research Board Special Report 242.

Hirschman, I., McKnight, C., Pucher, J., Paaswell, R.E. and Berechman, J., 1995. Bridge and Tunnel Toll Elasticities in New York: Some Recent Evidence, Transportation (22:2, pp 97-113)Holguın-Veras, J., Cetin, M., & Shuwen Xia, 2006. A comparative analysis of US toll policy. *Transportation Research Part A* 40 852–871

Holguin-Veras, J., Ozbay, K. and de Cerreno, A., 2005. Evaluation Study of Port Authority of New York and New Jersey's Time of Day Pricing Initiative, Final Report.

Hotopp, U., 2002. Teleworking in the UK, Labour Market Trends (110(6), 311-318).

Hughes, G. and McCormick, B., 1991. Housing Markets, Unemployment and Labour Market Flexibility in the UK, in G de Menil and R.J. Gordon (eds), International Volatility and Economic Growth: The First Ten Years of the International Seminar on Macroeconomics, Elsevier Science.

Humber Bridge Board. 2011. http://www.humberbridge.co.uk/ .

Hyman, G., Bradburn, P. and Kastner, A., 2002. An econometric investigation of car use in the national transport model for Great Britain..

Jones, P. and Hervik, A., 1992. Restraining Car Traffic in European Cities: An Emerging Role of Road Pricing, Transportation Research (31, 272-292)

Keeble, D., Owens, P.L., Thompson, C. (1982) Regional accessibility and economic potential in the European Community, *Regional Studies* 16, 419-432.

Kim, J.H., Pagliara, F. and Preston, J., 2005. The Intention of Move and Residential Location Choice Behaviour, Transportation Systems.

Langmyhr, T., 2003. Personal Communication, Kommune of Trondheim Norway in Ieromonachou, P., Potter, S., & Warren J.P., 2006. Norway's urban toll rings: Evolving towards congestion charging? *Transport Policy* 13 367–378.

Larsen, O.I., 1995. The toll cordons in Norway: an overview. *Journal of Transport Geography* Vol 3, No. 3. pp. 187-197.

Lauridsen, H., 2011. The impacts of road tolling: A review of Norwegian experience. T*ransport Policy* 18 (2011) 85–91.

Luk, J.Y.K. 1999. Electronic road pricing in Singapore, Road and Transport Research (8(4), 28-40).

Matas, A. & Raymond, J., 2003. Demand Elasticity on Tolled Motorways. *Journal of Transportation and Statistics*. Volume 6 Numbers 2/3, 91-108

McQuaid, Prof R.W., & Greig, M., 2002. An Assessment of the Economic Impact of the Skye Bridge Tolls: Final Report prepared for Highland Council. Employment Research Institute and Transport Research Institute, Napier University. Edinburgh, Scotland.

Meland, S., 1994. RVU Trondheim 1992.-Evaluering av bomringen i Trondheim Renort STF63. A94006 SINTEF Samferdselsteknikk, Trondheim, Norway, 52 pp. In Larsen, O.I., 1995. The toll cordons in Norway: an overview. *Journal of Transport Geography* Vol 3, No. 3. pp. 187-197.

Meland, S., Tretvik, T. & Welde, M., 2010. The effects of removing the Trondheim toll cordon. Transport Policy 17 (2010) 475–485

Murray, A., 2007. Effects of toll removal on Tauranga Harbour Bridge, New Zealand. Land Transport New Zealand Research Report 313. Beca Infrastructure Ltd, Auckland, New Zealand.

Odeck, J., Brathen, S., 2002. Toll financing in Norway: the success, the failures and perspectives for the future. *Transport Policy* 9, 253–260. In Ieromonachou, P., Potter, S., & Warren J.P., 2006. Norway's urban toll rings: Evolving towards congestion charging? *Transport Policy* 13 367–378.

Odeck, J. & Brathen, S., 2008 Travel demand elasticities and users attitudes: A case study of Norwegian toll projects. *Transportation Research Part A* 42 (2008) 77–94.

Oum, T.H., Waters, W.G. and Yong, J.S. 1990. A Survey of Recent Estimates of Price Elasticities of Demand for Transport, World Bank Working Paper.

Quddus, M.A., Bell, M.G.H., Schmocker, J. & Fonzone, A. 2006. The impact of the congestion charge on the retail business in London: An econometric analysis. *Transport Policy* 14 (2007) 433–444

Ribas, E., Raymond, J.L. and Matas, A. 1998. Estudi Sobre la Elasticitat Preu de la Demanda de Trafic per Autopista, Departament de Politica Territorial I Obres Publiques.

Rice, P, and Venables, (2004), Spatial Determinants of Productivity: Analysis for the Regions of Great Britain A CEP Discussion Paper No 642.

Rotaris, L., Danielis, R., Marcucci, E. & Massiani, J., 2010. The urban road pricing scheme to curb pollution in Milan, Italy: Description, impacts and preliminary cost–benefit analysis assessment. *Transportation Research Part A* 44 (2010) 359–375

Ruiz, Y. and Walling, A., 2005. Home-based working using communication technologies, Labour Market Trends, October, 417-426.

Shaoul, J., Stafford, A. & Stapleton, P., 2011 Private finance: bridging the gap for the UK's Dartford and Skye bridges? *Public Money & Management*, 31: 1, 51-58.

Sharpe, A, Arsenault, J, and Harrison, P, (2008) The relationship between labour productivity and real wage growth in Canada and OECD countries, CSLS Research Report No. 2008-8.

Shields, M. and Swenson, D., 2000. Regional Labor Markets: The Relationship Between Industry Level Employment and In-commuting in Pennsylvania Counties, The Journal of Regional Analysis and Policy.

Spatial Economics Research Centre, London School of Economics, (2009) for The Northern Way *Strengthening economic linkages between Leeds and Manchester.*

Standing Advisory Committee for Trunk Road Assessment, 2000. Transport investment, transport intensity and economic growth: interim report.

Steer Davies Gleave, 2007. Toll Impact Study: Final Report. Prepared for the Scottish Executive.Welsh Affairs Committee, 2010. Third Report: the Severn Toll Crossings.

Wentworth, M. A., & Beresford, A., K., C. 1998. Major U.K. tolled road crossings reviewed *Transport Policy* 5 5l-59

Weustefield, N.H. and Regan, E.J., 1981. Impact of rate of increase of toll facilities, Traffic Quarterly (34, pp. 639-655).

White, P.R., 1984. Man and his behaviour Part 4a. User response to price changes: application of the ‘threshold’ concept, Transport Reviews: A Transnational Transdisciplinary Journal.