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consultancy engineering business environment

Infrastructure: A case for funding

November 2010

Review of infrastructure projects, literature, and the challenges ahead

Executive summary

This report aims to review and analyse a range of material that is openly available (such as economic papers, cost benefit analysis and case study evidence) in an attempt to ascertain what effect infrastructure investment has on the economy. This paper will not however go into the mechanisms that would fund such projects but attempt to demonstrate the scale of potential the contributions the construction and infrastructure sector could make.

The economic rationale behind investment decisions has not been as important as it is during this economic cycle given the recent recession, tightening credit conditions and proposed public sector cuts. Projects need to demonstrate that they will improve the future growth prospects of the UK.

The return upon infrastructure investment was found to vary significantly not only between projects, but also across countries. Theory suggests that achieving a positive economic effect from investment relies on the current level of provision in respect to that of the optimal (equilibrium level), maintaining the long run competitiveness of the economy, investor certainty, access to capital, accounting for externalities and market failure, and creating a conducive regulatory environment.

Inferences from economic papers

The economic papers reviewed as part of this report display a wide range of views and findings. The effects of infrastructure upon economic growth are by no means consistent in magnitude but more often than not appear to be complimentary in terms of their impact upon growth.

Égert, Kozluk and Sutherland (2009) identified that network investment within their sample of OECD economies accounted for between one tenth and one quarter of economy wide investment. This is substantial and suggests that investing in both new and existing infrastructure is important for economies in terms of meeting consumption and consumer needs as well as attracting future potential business opportunities.

However, investment figures contain a degree of uncertainty in respect to the definition of public capital and identification of its components. Government spending data is not always available and the definition and inclusion of projects

within this data vary from country to country. Initiatives such as Private Finance Initiatives (PFI) and Public Private Partnerships (PPP) also result in further definition issues clouding investment figures further. For this reason a number of the studies utilise physical measures of capital, such as the length of roads, railways etc. These also do not necessarily place the degree of emphasis on the financial implications of infrastructure required and both methods provide at best a rudimentary measure of quality, which can account for significant variations in costs and the subsequent level of externalities. For example, appendices B and C explore data within the UK showing the utilisation, satisfaction and safety of the UK.

Another area which continues to be debated is that of the spillover effects and the manner in which these effects should be modeled. J.P. Cohen, (2007) in his paper outlines that "a positive spillover occurs when other agents' actions confer benefits on an individual while the individual does not provide any compensation for these benefits."

These effects are debated in terms of their significance on neighbouring areas and consumers at both a domestic and international level. The effects can be both positive and negative given their potential to attract and draw investment to surrounding areas.

Air travel was cited as an example where improving an individual airport and/or hub will not only improve the routes operating through it but will also feed through to airports that do not operate services directly out of that location. Ultimately, the investment improves the operation of the whole system.

However, modelling transportation networks such as roads presents a far greater challenge in terms of the potential knock on and spatial effects. This is partially down to the point to point nature of the travel; this means that there are a greater number of routes and variables to account for within the econometric model. This can result in higher levels of uncertainty, a potential loss of functional form, multicollinearity and so an inaccurate estimation of any benefits/costs of such investments.

Some of the 'softer' forms of infrastructure such as telephony and mobile network systems have provided one of the better returns on investment in terms of the level of growth provided over the past 25 years. Contributory factors to this are the

ease to which such services have been integrated into daily business regimes and the speed of their deployment.

However, some forms of infrastructure are beginning to show reduced or negative contributions to growth. This may be because the economy is approaching the optimum level of provision of output; that is to say, that the magnitude of the benefits from the investment does not equate to the cost of supply such services. This has always been applicable within an economy and demonstrates the need for investments to be made in a manner that is cost effective and if possible at a price the market deems suitable. There must also be recognition that some services (public goods and merit goods) would not be provided freely by the market or at a level that is deemed socially acceptable given the positive externalities they exhibit.

If you were to apply the above to the UK's current infrastructure challenge, for example, the positive externalities of renewable forms of energy production, theory suggests that the market does not fully recognise the potential dangers of climate change (please refer to appendix D for an overview of the UK's environmental statistics).

It is for this reason that the government has incentivised renewables developments through mechanisms such as feed in tariffs, ETS and the taxation system. Investment in these markets, given their importance, will influence the economic potential of an economy given the future scarcity of resources and increasing prices.

It can be argued that intervention within markets creates distortions that in the long run will result in a sub optimal economic outcome. In the long run the private market should adjust its expectations and advances in technology will allow the above to occur in a manner that is incentive free. It could be argued that when we get closer to this point there will be significant increase in the levels of funding that is available for such projects.

The economic papers continue to demonstrate the complexity of investment decisions, and the importance of policy to create a conducive environment for investment and growth. Égert, Kozluk and Sutherland (2009) recognize the importance of policy and tested various environments in terms of their effectiveness to encourage efficient investment. They conclude that competition

within investment environments is important and that barriers such as vertical integration should be minimised with third-party access and barriers to entry reduced where possible.

It is also suggested that national plans help to 'frame infrastructure objectives' giving an indication to the markets as to the balance of public and private investment. These also help to provide a degree of certainty improving confidence amongst private investors. Within this contracts need to be well thought out and provide reasonable risk distribution. Models such as PPPs are explored further in Appendix F.

Overall, the papers reviewed provide a positive outlook on the benefits of infrastructure investment. Some negative effects occur but if infrastructure provision is excessive these effects are likely to be mitigated in the long-run given the likelihood of increasing demand patterns (assuming the technology does not become obsolete in the interim period).

Most importantly the papers have demonstrated the need for infrastructure investment projects to be economically efficient, targeting bottlenecks and inefficiencies within the existing systems as well as providing newer projects that increase overall capacity providing long term opportunities.

The UK's Current infrastructure

Appendix A explores in more detail the current competitiveness of the UK's infrastructure to that of other countries utilising The Global Competitiveness Report 2009-2010[1]. Initially it appears that the UK does not perform badly against the 133 other nations used in the comparison. However, if the UK thinks about its ratings in relation to its direct competitors for foreign direct investment there is cause for concern.

The UK ranked within the top 20 for infrastructure in only one category (quality of electricity supply) potentially meaning that we are in an unfavourable position when considering our direct competitors in the G8 and G20. The other categories included the quality of overall infrastructure, quality of roads, quality of railroad infrastructure, quality of port infrastructure and the quality of air transport

[1] The Global Competitiveness Report 2009-2010, World Economic Forum, http://www.weforum.org/en/initiatives/gcp/Global%20Competitiveness%20Report/index.htm

infrastructure. In addition to this there is likely to be increasing pressure to compete with emerging economies for resources.

A section of this paper explores in further detail the issues surrounding transmission, security of supply infrastructure efficiency, capacity and the challenges ahead for a number of sectors. We find that there still remain a significant number of engineering challenges to overcome, especially in respect to the creation of a low carbon economy, to meet the Government's 80% reduction target by 2050.

Inferences from case studies

This paper looks at the Department for Transports Eddington Study, Crossrail and several highways agency projects. These are used as a means of testing the depth and requirements of project scopes and analysis, and in the case of the highways agency to ascertain if the anticipated benefits are realised after project completion. The studies into Crossrail shows that project investigations are becoming more detailed in nature and attempt to include both the wider economic benefits and the environmental impacts of such schemes. Improvements in modelling techniques will continue to enable policymakers to make informed decisions as to which projects will be of greatest benefit to the UK's prosperity. For example, it is predicted that the total user and welfare benefits from Crossrail will range between £30bn-£42bn and the economic benefits £36bn-£67bn.

The Highways Agency schemes which are much smaller in scale also demonstrate good value for money, with economic benefit cost ratios (BCR) of approximately 2 times or greater. The appraisal process and post project evaluations also show that the highways agency, designers and contractors are aware of the government's commitment to reduce the environmental impact of projects.

Although the UK will benefit from national projects, such as Crossrail and high speed rail, smaller targeted projects continue to hold a lot of economic potential. For this reason it is important that government policy is wide ranging. A situation whereby government adopts a 'tunnel vision' policy approach (focusing upon only the large iconic projects) would potentially be detrimental to economic growth. It is important to remember that the existing infrastructure forms an integral part of UK transportation, transmission, etc. If these connections are allowed to degrade, apart from the direct implications to economic growth these poorer connections

will ultimately negate the benefits of any new infrastructure as the economic benefits are not transmitted as effectively to different parts of the economy.

The Eddington Transport Study

The Eddington Transport Study attempts to estimate the wider economic benefits of transportation investment and its reported wider BCR estimates show that the narrow GDP measure misses a very substantial proportion of the benefits provided by these projects, particularly on public transport schemes.

The study adds further weight to the case studies within this report with similar rates of returns being reported. It also provides some insight into the 'wider costs and benefits' which is important given that more projects are likely to require impact assessments within these areas.

In terms of targeting investment the report also demonstrates that directing funds to smaller 'congestion relieving' projects should provide significant returns. Despite this, it should be noted that larger projects still provide returns 2-5 times that of the initial investment, and unlike smaller projects they are more likely to secure, and substantially increase long term capacity.

Ultimately, achieving a balance of investment in long term capacity and congestion relief is vital to meet any future economic challenges.

Concluding remarks

This report has demonstrated that efficient investment in infrastructure can provide significant economic benefits. Although larger scale projects have the potential to significantly influence long-term capacity and economic growth, this report has demonstrated that smaller projects are just as vital to remove congestion and bottle necks within the UK's current system. These improvements result in efficiency, safety and possibly environmental gains which will all feed through into the wider economy promoting growth.

Introduction

This paper is intended to analyse and review the contribution construction and infrastructure makes to the UK economy, the causality and scale of its effects and the potential externalities involved with such projects. This should help to determine the overall effect such investment has on both the short run and long run economic position.

This research is supplemented by previous papers from ACE, these outline a variety of funding methods, along the lines of both more traditional and new forms of infrastructure spending stimuli.

- The Infrastructure Investment Trust - ACE proposes a supplementary model to PFI initiatives, to read the executive summary please click here
- Retrofitting the UK's housing stock - This paper is intended as a conversation starter on how retrofitting might be taken forward in the residential sector
- Department for Infrastructure - ACE makes the case for a new department to support government and infrastructure
- Spending efficiency - This paper makes the case for a balanced scorecard approach to achieving efficiency
- Infrastructure funding - a range of options in its latest policy paper: Infrastructure Funding
- Avoiding the infrastructure crunch - ACE identifies the problems and suggests policy solutions
- Infrastructure bank - ACE sets out the case for an infrastructure bank
- Infrastructure gilts - ACE's proposal to create an infrastructure gilt to drive investment in transport, energy and utilities and
- Infrastructure assessment - ACE's proposal for an audit of the UK's existing infrastructure

Infrastructure – building a better future

Infrastructure investment and improvement has been a key feature of the recovery packages put in place by European governments during the economic crisis. The argument is that such improvements will place the economy on a better footing to deal with both the current economic challenges and will provide enhanced capacity, and opportunity, as economic growth returns.

This demonstrates the importance of understanding how capital spending influences both our businesses' competitiveness and our economic environment. When government and/or private corporations invest they are sacrificing current expenditure and wealth for the prospect of increased future income and returns. Based upon this ideal alone, no untenable projects would take place given that the current cost of undertaking them was not economically efficient, all investment should therefore produce an 'economic profit' given that the opportunity cost of all inputs would have been accounted for.

However, investment decisions are complex and expectations surrounding future market conditions are often inaccurate. Despite the continuing improvement of modelling techniques over the past 30 years, and the attempt to further account for items such as spatial effects, not all information can be included within a model. Some aspects are very difficult to accurately quantify.

Albert Einstein sums this up quite nicely: "Everything that can be counted does not necessarily count; everything that counts cannot necessarily be counted."

These models have to be a 'correct fit' to provide an accurate representation of the conditions you seek to predict, and whilst we have come a long way in terms of statistical analysis and econometric techniques, calculating the 'future benefit' for any given project still remains complex.

Increasing awareness of economic conditions and the potential positive and negative externalities a project may entail has resulted in an increased need for consultants, contractors and engineers to demonstrate the 'wider range' of social, environmental and economic benefits.

If a simple list was created of the possible externalities and inferences that could be ascertained or derived from investment in infrastructure it may look something like the list below.

Economic benefits

- Business revenue growth
- Wages growth
- Employment prospects
- Improved productivity
- Reduction of businesses operating costs
- Expanded production possibility frontier (economic capacity)
- Improved journey times and efficiency
- Attractiveness to investors

Social benefits

- Improved living standards
- Local regeneration
- Increased levels of safety
- Aura / feel good factor effect
- Health benefits
- Human capital - educational benefits

Environmental benefits

- Emissions reductions
- Wildlife conservation schemes
- New construction can utilise modern materials with lower carbon footprints
- Reduction in maintenance, reducing raw material needs

These benefits will differ between types and sizes of projects, as will the extent to which they influence the wider economy and social conditions. The interaction between the above variables is also not always ‘certain’ and so adds further complication. For this reason it is important to continue to explore the mechanisms that tie infrastructure into the wider economy. This should help to ensure that as a sector our solutions are ‘future proof’ standing the test of time.

Infrastructure's direct effects

It is important to remember that not all the benefits derived from infrastructure projects occur in the long run. Some of the economic advantages take place within the current economic period.

The short run effects listed below are direct in nature. They do not include the spatial or 'knock on effects' that subsequently take place over the medium or long run periods.

- The initiation of a project will result in the utilisation of labour within an area- creating jobs. In addition to this the workforce is constantly adapting and improving its skills base, enhancing the flexibility of the UK's labour market.
- The company employed to undertake the work will benefit directly from the revenue stream.
- Efficiency of stock – the new infrastructure should outperform its predecessor, benefiting from improved capacity and efficiency. Although there may be significant capital spending there should also be a reduction in the direct (short run) maintenance costs.
- Environmental impacts – infrastructure projects will directly affect the immediate area in terms of the environment that surrounds it. This could be positive or negative depending upon the type of project undertaken.

The indirect (spatial) effects of infrastructure

The above effects of infrastructure spending stopped at the first incidence of any perceived benefit. However, economic conditions are far more complex and the interactions within an economy can create multiplier effects. Modelling these effects accurately and their subsequent impact is the goal of statisticians and economists.

Unfortunately, current modelling techniques cannot fully account for such circumstances and so still give a distorted picture of the 'true' benefits and costs of infrastructure.

Below are some examples of the kind of mechanisms through which infrastructure spending can translate its benefits, improving economic growth by a factor greater than that of the sum of the initial investment.

- When completed new infrastructure is likely to provide increased capacity and efficiency this subsequently results in a reduction in the 'economic' cost to users, whether directly as a result of price reductions or as a result of time savings which increase productivity. These productivity gains may subsequently generate additional revenue as users can participate in other economic activities.
- New infrastructure factors positively within companies' decisions to invest. This provides growth within the labour and housing markets, which increase the level of consumer activity, improving trading conditions. As local businesses grow they continue to benefit from such activities, increasing wages and employment; these subsequently feed back into the local economy in the form of increased wealth which will further improve their revenue streams and ultimately improve the aura and desirability of the area, which will attract further people and investment expanding businesses' potential customer base.
- The mechanism above increases long term demand for labour, which should improve the skills base of the local population, reducing structural unemployment.
- Increases in wealth within an area will also feed through into tax revenues allowing local councils to increase spending, promoting regeneration and further economic stimuli. These in turn provide jobs which increases consumption, further promoting economic growth.
- Infrastructure assets may also have the added benefit of reducing the environmental impact of business activity. This carries benefits with regards to meeting national targets and improving social responsibility.
- Investment may lead to improvements in health (via improved facilities, environmental conditions, response time savings), if this is the case the local economy will benefit from higher productivity and participation rates. In addition to this the fiscal burden on local councils of providing medical facilities and treatments should also be reduced.
- Improvements in one area may also alleviate problems in neighbouring areas. A good example of this happens when considering the impact of road schemes. The result can be that a number of towns or boroughs may benefit from improvements in capacity and productivity which will improve businesses

earnings which feed through into higher wages, higher employment and increased levels of consumption.

The above demonstrate that investment in infrastructure has the potential to generate economic growth and benefits through a variety of mechanisms resulting in benefits in excess of those that equate to the initial investment.

Margaret Thatcher, for example, stated: "You and I come by road or rail but economists travel on infrastructure."

This demonstrates that although consumers may not actively think about and/or appreciate infrastructure, it plays a vital role in both the economy and our daily lives.

This raises the question of where the UK's current infrastructure challenges lie and how we determine the economically efficient level of provision. One aspect which is likely to feature significantly in any future projects is that of low carbon technologies, given the political will and growing global desire for positive action.

Low carbon technologies provide interesting opportunities for engineers and consultants not only in terms of the potential market growth but also with regards to technological progress, and the provision of innovative solutions.

These solutions may need to account for both operational and embedded carbon demonstrating improvements in process, building materials and ultimately the way in which the final product is utilised. Today's engineers, like their previous counterparts of the 18th and 19th centuries, will have to think outside of the current norms and create some truly inspiring projects.

Ronald Reagan surmised the link between human endeavour and growth quite nicely: "There are no great limits to growth because there are no limits of human intelligence, imagination, and wonder."

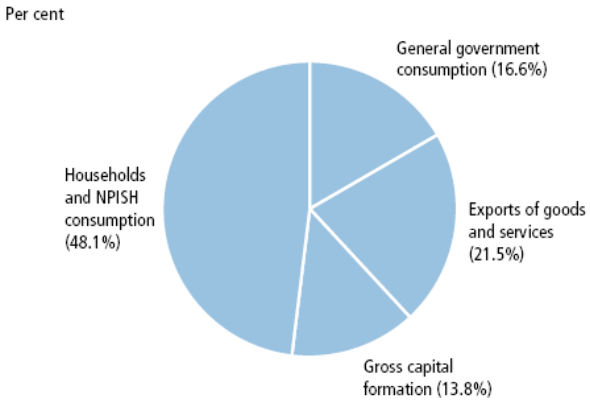
Construction's contribution to the economy

Within an economy there are many factors which influence economic growth through a variety of complex mechanisms. Ultimately the effects will translate through either the demand and/or supply aspects of the economy.

The Blue Book 2009[2], published by the Office of National Statistics (ONS) "contains the estimates of the domestic and national product, income and expenditure of the United Kingdom."

From this we can gauge the size of the construction sector within the UK and its relative importance to GDP growth.

GFE at current prices: share by category of expenditure



Source: ONS

"Gross final expenditure (GFE) measures the sum of final uses of goods and services produced by, or imported to, the UK." As can be seen from the above chart in 2008 the largest category of expenditure in the UK continued to be that of Households and Non-profit institutions serving households (NPISH) consumption accounting for 48.1% of total expenditure.

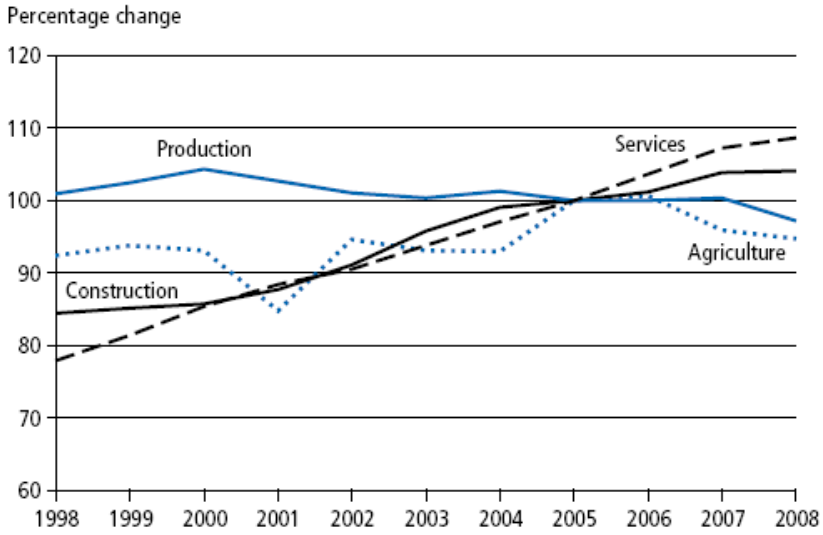
The remaining expenditure is attributable to the export of goods and services (21.5%), general government consumption (16.6%) and gross capital formation

[2] Source: ONS, United Kingdom National Accounts: The Blue book 2009 http://www.statistics.gov.uk/downloads/theme_economy/BB09.pdf

(which accounts for acquisition less disposals of fixed assets and the improvement of land – 13.8%).

Each of the above categories will entail some activity within the construction, manufacturing and engineering sectors. As capital goods are invested in, products and services purchased, contracts procured from government and employees paid, this feeds through into household consumption which may include the consumption of construction and building services.

Lookin0g at industry trends over time, the annual plot of Gross Value Added (GVA) indicates that the construction sector has continued to expand since 1998, although the period 2007-2008 remained relatively unchanged, compared to a 3.1% fall in the production sector and a 1.3% rise in the services sector.

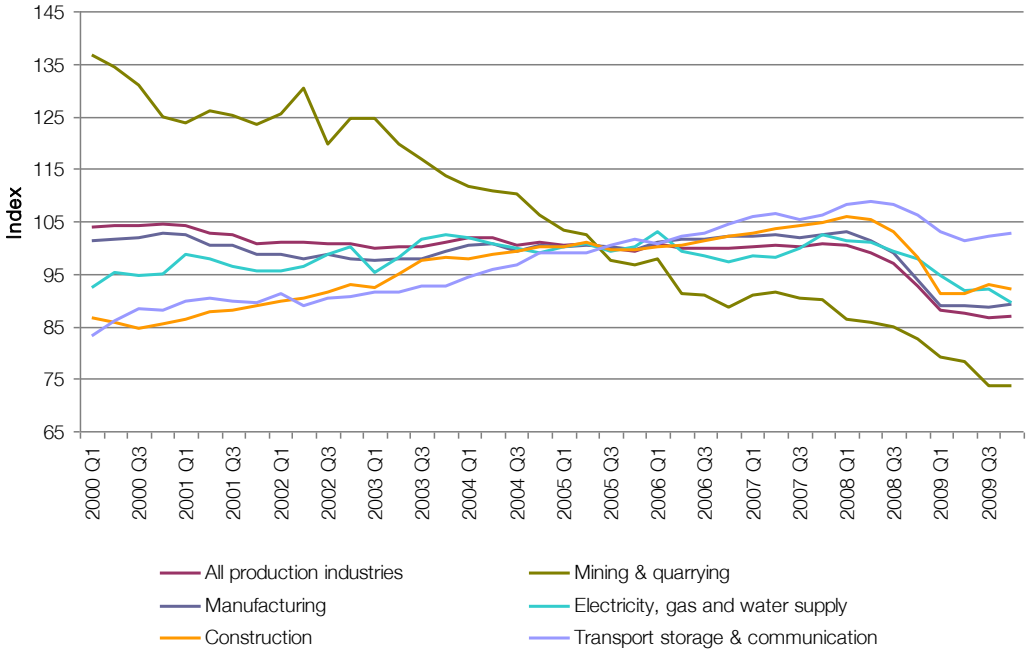


Source: ONS

However, the above does not yet show the effects of the recession and it is possible to segment further the sectors which contribute, and would be integral, to infrastructure investment.

If the quarterly GVA index (shown below) is plotted across a wider variety of industry (manufacturing, construction, production and material sectors) it can be seen that the construction sector has continued to expand in terms of the value it adds to economic output in relation to these other industrial sectors.

The effects of the financial crisis and recession are also instantly recognisable with the GVA of all industries falling after 2008Q1.



Source of data: ONS - Gross value added at basic prices: CVM: Seasonally adjusted, 2005 = 100

Policy Exchange's Delivering a 21st Century Infrastructure for Britain report[3] stated that Britain has an infrastructure deficit requiring at least £434 billion of new investment by 2020.

This aggregated amount is broken down as follows:

- Energy £264 billion
- Transport £120 billion
- Communications £5 billion
- Water £45 billion
- Total UK infrastructure deficit of £434 billion[4]

If the UK were to put in place the adequate funding mechanisms to meet the requirements above, the construction sector would likely contribute to a greater proportion of the UK's output (assuming that investment and growth in all other sectors does not simultaneously outstrip that of the construction sector).

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[3] *Helm, D, Wardlaw, J & Caldecott B, 2009, Delivering a 21st Century infrastructure for Britain, Policy Exchange*

[4] *According to Policy Exchange this figure is based on estimates of "simultaneously replacing aging infrastructure and investing in new infrastructure to improve our competitiveness, while meeting the challenge of decarbonisation" (2006:p6). This is seen as a conservative financial estimate and is on top of the spending needs of public sector infrastructure in schools, hospitals and IT systems.*

This infrastructure capacity may help to attract foreign direct investment and drive the UK's low carbon economy.

Appendix A explores in more detail the current competitiveness of the UK's infrastructure to that of other countries utilising The Global Competitiveness Report 2009-2010[5].

The following UK rankings are ascertained as part of the report:

- Quality of overall infrastructure 33rd
- Quality of roads 30th
- Quality of railroad infrastructure 21st
- Quality of port infrastructure 31st
- Quality of air transport infrastructure 35th
- Quality of electricity supply 18th

Initially the above statistics would appear to suggest that the UK does not perform badly against the 133 other nations used in the comparison. However, if we think about this in terms of our direct competitors for foreign direct investment there is cause for concern. The UK ranked within the top 20 for infrastructure in only one category (quality of electricity supply - please note that this has no inference on the levels of capacity or security of supply), potentially meaning that we are in an unfavourable position when considering our direct competitors in the G8 and G20. In addition to this there is increasing pressure to compete with emerging economies for resources and funds.

Given the above, this report will now analyse in more details where the UK infrastructure challenges lie.

[5] The Global Competitiveness Report 2009-2010, World Economic Forum, http://www.weforum.org/en/initiatives/gcp/Global%20Competitiveness%20Report/index.htm

Infrastructure challenges

The case for funding

Strategic investment in the UK's infrastructure network will lead to increased economic activity as well as providing the infrastructure that the UK needs to get from A to B, live in a sustainable way and raise revenue for government.

High quality infrastructure assets enhance a country's national output. It has been argued that a large part of private sector productivity growth is connected to the size of a country's infrastructure base and annual investment in it[6].

Infrastructure spending generates a large multiplier effect across the full economy by creating additional demand for materials and services. Indeed, £1 spent on construction output produces almost £3 in total economic activity, meaning that construction can be one of the most effective sectors to stimulate demand. This can be compared with other sectors:

Sector	Short term multiplier*
Construction	£1 spent = 2.09
Agriculture	£1 spent = 1.92 (approx)
Banking & finance	£1 spent = 1.72 (approx)
Public administration	£1 spent = 1.30 (approx)

Source: UK Contractors Group[7]

**(not including induced impacts and long term effects. If these were integrated into the calculations they would produce almost £3 in total economic activity)*

The Eddington Report[8] suggests that the economic yield of targeted infrastructure investment can be up to a factor of 10. Therefore, £1 billion spent could add around £10 billion of economic activity. The UK can stimulate its economy during the downturn as well as increasing its long term competitive advantage through

[6] Rodgriguez, F, 2006, Have collapses in infrastructure spending led to cross country divergence in per capita GDP? Wesleyan University

[7] LEK/UKCG, 2009, Construction in the UK Economy: The Benefits of Investment

[8] Eddington, R, 2006, The Eddington Transport Study, The case for action.

investing in its transport, energy, communication and social infrastructure. There is then a ‘dual dividend’. A dedicated, smart and integrated investment programme can achieve several public policy goals simultaneously. Furthermore, with interest rates at all time lows it is an ideal time for the public and private sectors to invest.

Utilities - electricity, gas and water

Energy – electricity and gas

- Integration of renewables
- New generation capacity
- Smart Grids
- Energy Efficiency
- Transparent market prices

Water

- Addressing the UK's investment timings – amp cycle
- Directing investment – sewage, flood defences, water treatment, pipes
- Meeting demand and environmental targets

The energy and utilities markets have been of more interest recently, with regards to investment, service quality, security of supply and pricing.

The gas industry, in particular, has been through several political and meteorological challenges, with Europe evaluating security of supply issues after Russia turned off the taps following a dispute with the Ukraine. The UK despite feeling little effect of such action did feel the squeeze in January 2010 when a prolonged period of cold weather depleted gas reserves and demonstrated the fragility of the UK storage capacity.

The electricity sector is also not without its issues. With a number of nuclear stations due to close within the next 10-15 years the UK potentially faces the prospect of the lights going out. Environmental requirements, the collapse of the ETS carbon price and a lack of confidence to invest all have the potential to exacerbate the problem for the foreseeable future.

Finally, the water sector is also struggling, with companies struggling to retain staff as the Asset Management Programme creates cyclical peaks and troughs in volumes of work. The current investment priorities are also somewhat confused with environmental considerations, the possible need for flood defences in the face of climate change and the requirement to improve not only water quality but also supply security.

The common theme running throughout all of these sectors is the need for investment, but where should these investments occur and will they provide sufficient returns for investors and secure future economic growth?

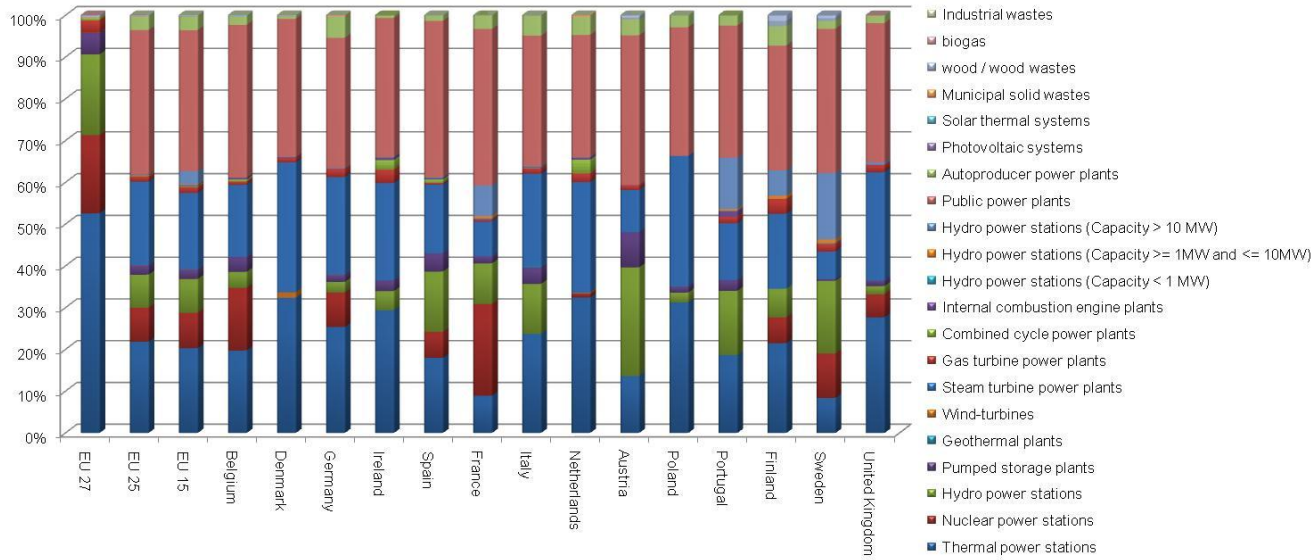
Below is a selection of data relating to each sector, and further commentary upon the trends and challenges we face.

Electricity production

Within the electricity sector there is a need for the UK to address issues of security of supply whilst improving the environmental performance of generation.

Below are a variety of countries, and using Eurostat data their generation mix has been plotted using the net installed capacities for 1990 and 2007.

1990 – Net installed capacity – by type and country

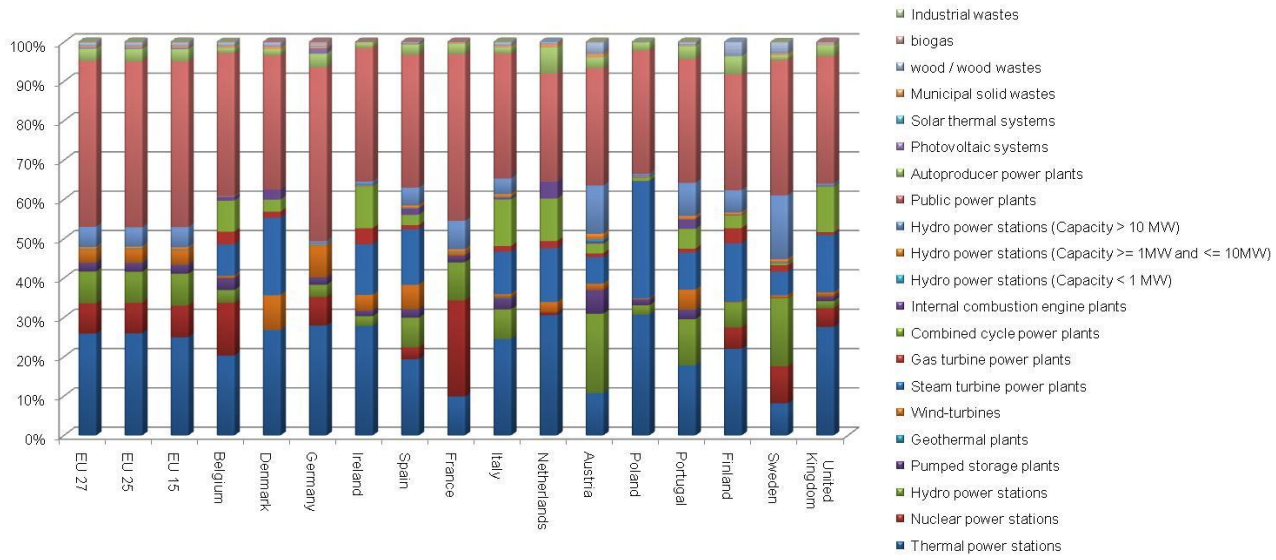


Source: Eurostat

In 1990 a substantial amount of net installed capacity was attributable to four main types of generation: public power plants, thermal power stations, combined cycle power plants and steam turbine power stations.

This generation mix relies heavily on fossil fuels but does have the advantages of providing stable base load generation.

2007 – Net installed capacity – by type and country



Source: Eurostat

The change in investment priorities over the period can be seen when you compare 1990 to 2007, the generation mix has moved towards that of low carbon generation. It should be noted that generally countries have increased their generation mix which should help to ensure security of supply. Secondly, there is much wider use of a hydro power stations and wind turbines, with early shoots also appearing on some countries with regards to solar, wood/wood wastes, industrial wastes and biogas.

It is reasonable to assume given the continuing political commitment within the EU to renewables, energy efficiency and the reduction of carbon emissions that this trend should continue. The financial crisis has however made investment decisions more complex with uncertainties as to the funding and the return available from renewables projects. There is also the issue of intermittency with renewable sources of generation. This requires either base-load stations to be on standby or a substantial power grid network that could transfer large amounts of energy across a multitude of destinations across a much wider geographical area (such as an EU grid, this would stagger demand from differing time zones and helps to combat intermittency with varying local conditions and a wider generation mix).

Ofgem recently published, Project Discovery: options for delivering secure and sustainable energy supplies[9] in which they proposed a number of initiatives to encourage investment within the energy sector.

It is important to relate energy usage to investment, in the UK energy usage has been relatively stable for the past ten years, showing only a very slight increase over the period.

The recession will have reduced energy usage as consumers become price sensitive and businesses reduce output in line with falling demand. However, when economic conditions improve energy usage is likely to return to its pre recession levels and upward pressures will increase as demand for electronic goods and potentially even electric cars increases. Improvements in energy efficiency and technology will help to mitigate these increases to some extent but ultimately an increase the UK's energy capacity will be required.

Gas supply and transparency

The gas sector is currently under pressure from the European Commission to have greater transparency of contracts and pricing. This follows moves in the electricity sector which helped to promote competition between suppliers, benefiting consumers. It is important to recognise that there are some differences between the fundamentals in the two markets. Whilst electricity can be produced locally through a variety of methods, gas has to be transported from its source to the location it is required. This potentially means there is far less scope for competition given the large sunk costs and limited number of suppliers that have the resources to access such supplies. Secondly, unlike electricity gas can be stored which does provide some flexibility within the system without ensuring that the system is continually balanced via complex balancing systems.

Although the UK has a single standard for gas there are different qualities of gas across Europe, these add an extra layer of cost to the movement of gas.

Finally a large amount of gas is transported and purchased via the use of long term contracts, this provides little opportunity for 'new' competition to enter the market with limits on transmission and difficulty competing on price.

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[9] Source: Ofgem (2010). Project Discovery: options for delivering secure and sustainable energy supplies, www.ofgem.gov.uk.

The issues above, although relating to Europe and not just the UK, are important given that the gas markets is more competitive internationally given that it can't be produced locally. The increasing import dependence of the UK for gas also means that we are going to be more reliant on Russian and Liquefied Natural Gas (LNG). This is important given that if the price for LNG is greatest in China this is where companies will deliver, despite there still being demand in the UK. It is only when prices in the UK are preferable that supplies will be imported.

Water

The water sector faces a number of challenges. Ultimately pressures take the form of keeping consumers bills 'reasonably' constrained whilst encouraging companies to undertake significant investment in an ageing network.

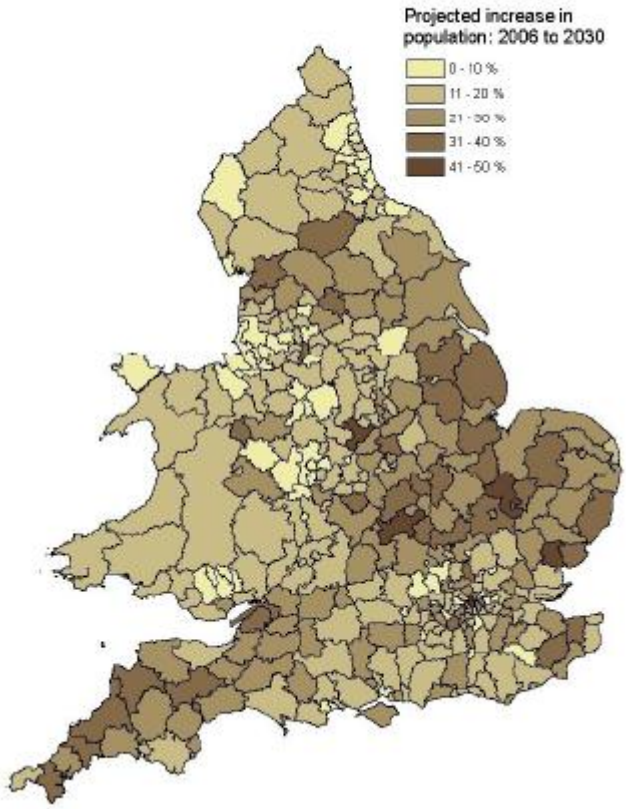
Investment in the UK is required to reduce leakage rates, improve sewerage so as to minimise river discharge, continue to improve water quality, ensure security of supply, improve flood defenses and to lower the environmental impact of the water sector.

Within the above, climate change and environmental legislation has the greatest potential to exert upward pressures on the cost of Capex and Opex spending.

- Climate change may result in increased intensity and frequency of events such as flooding, this will require investment within defenses, drainage and possibly storage facilities.
- Deterioration in environmental conditions (such as rubbish in rivers, pollution from the atmosphere and pesticides and fertilizers run-off from agricultural land) is likely to result in an increased need for water treatment facilities as water quality falls.
- Increased spending on costal defenses from any possible sea levels rises.
- Utilising efficient and environmentally friendly construction techniques lowering the water industry's carbon footprint. Currently new technologies such as these are more expensive than older less experimental technologies.

Further investment in the water industry is also going to be required as the UK's population increases. Below is a projection of the population increases expected in

DEFRA's "Independent Review of Competition and Innovation in Water Markets: Final report[10]"



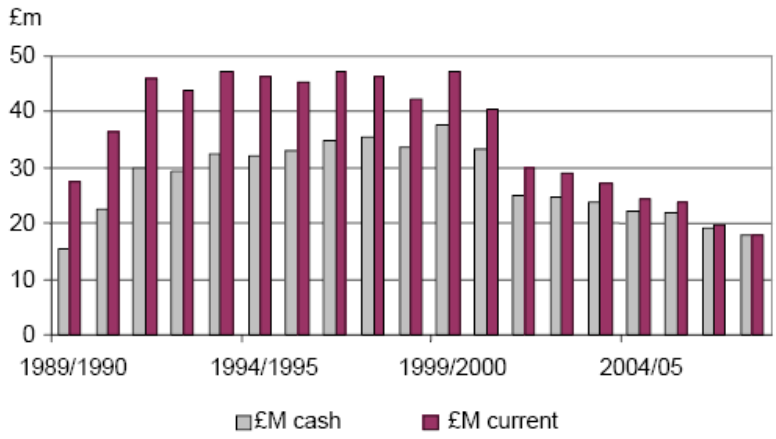
Source: DEFRA

This demonstrates that potentially a significant of investment will be required within the Midlands, South East, South West and Northern parts of the UK.

This report also provides an indication as to how research and development funding has changed since 1989/1990. Below is the chart and subsequent evaluation of water companies' spending.

[10] Source: DEFRA "Independent Review of Competition and Innovation in Water Markets: Final report" (April 2009) http://www.defra.gov.uk/environment/quality/water/industry/cavereview/documents/cavereview-finalreport.pdf

Chart 7.A: Research and development spending by water companies. Data excludes water only companies



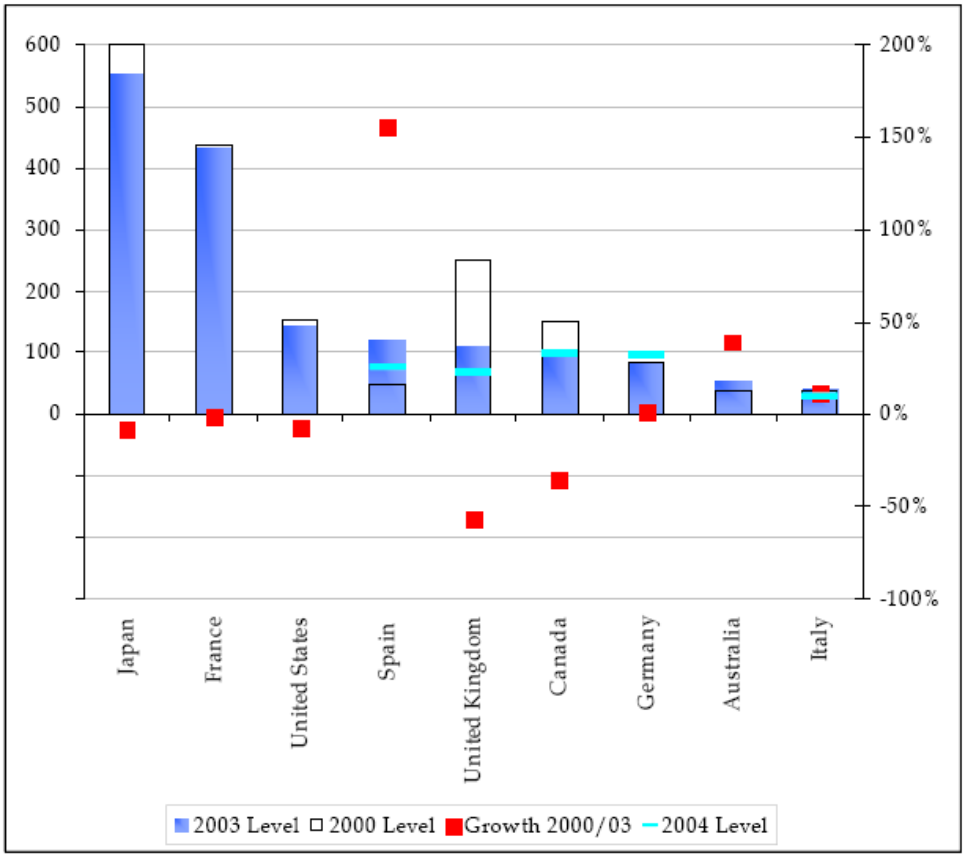
- "For companies that carry out research and development from operating expenditure, such spending is considered alongside other operating expenditure priorities and is subject to the same efficiency assumptions and comparisons."
- "While the level of spending on research and development doesn't capture the quality of expenditure, it does provide a useful indicator of the volume of spending. In real terms, the amount of reported operational expenditure on research and development has fallen from £45 million a year in the early 1990s, to £18 million today."

A further report published by London Economics entitled "Innovation in the water industry in England and Wales[11]" draws on data to make some comparisons with other countries. Below are some of their findings:

One of the first interesting comparisons made in the report is that of R&D expenditure in the electricity, gas and water industry for the nine countries. The data ranges from between 2000 and 2003 although some data is shown for 2004 where available.

[11] Source: DEFRA, paper by, London Economics, Iinnovation in the water industry in England and Wales, (Feb 2009), http://www.defra.gov.uk/environment/quality/water/industry/cavereview/documents/london-economics-summary-research.pdf

Figure 1: Business enterprise expenditures in Research & Development (current $m PPP)



Source: OECD, ANBERD database, 2006.
Note: data are not available for 2004 for Japan, France, USA and Australia

Source of chart: London Economics, DEFRA

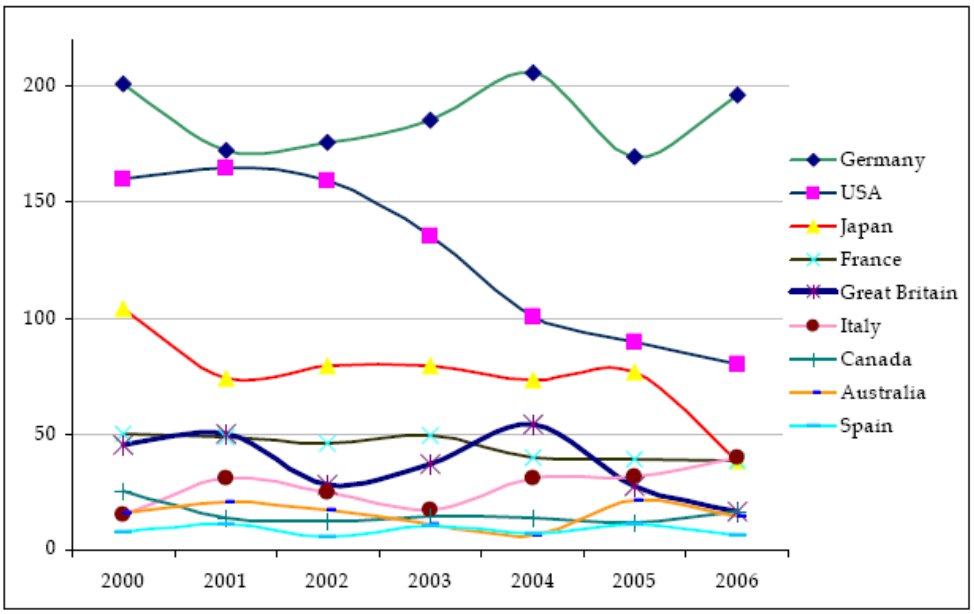
- In 2000 the UK had the third highest level of R&D spending in these sectors at $250m, however this fell substantially to only $68m in 2004.
- When calculating the 2000-2003 growth rate the UK's decline in R&D expenditure was the greatest of the nine countries included in the study.

Although the relates to water, electricity and gas it does raise some concern as to the levels of R&D spending when compared to other countries.

Further to this, data is also provided for the level of patent applications within the water and waste treatment sectors. Although this is not a totally accurate barometer for innovation, given that existing technologies can be used in 'new

innovative ways', it does provide some indication as to how innovative the water sector is in each country.

Figure 5: Data on patent applications - Water & Wastewater Treatment



Source: OECD data
Note: Count of relevant patent applications, classified by inventor country (using fractional method).

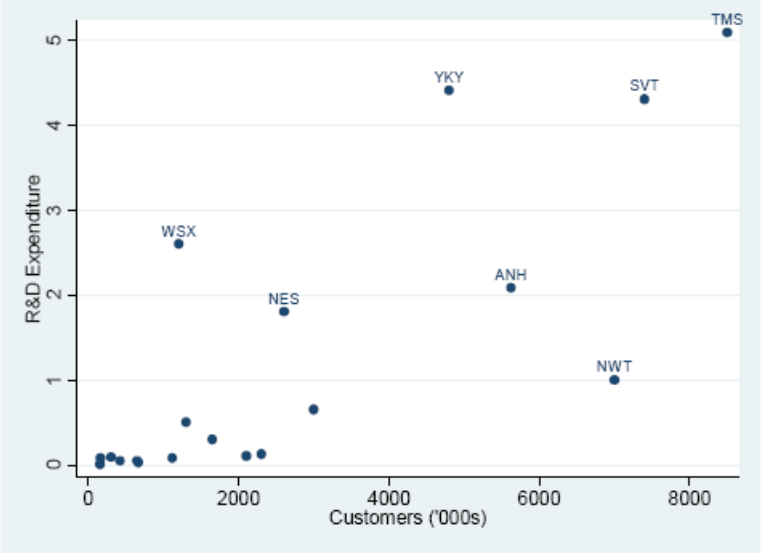
Source of chart: London Economics, DEFRA

Overall there has been a decline in patent applications across all countries with the exception of Germany.

The above two sets of data provide a worrying trend given that in the UK both R&D and patient applications are falling. This would suggest that currently and in the foreseeable future there is the likelihood of constrained innovation, given that the implementation of new technologies and building of new systems is likely to lag significantly behind the initial R&D spending. Given that there will be a period of several years between spending upon R&D, and the filing of any patents followed by further delays as pilot projects are undertaken and tested before the product finally reaches the market.

Further to this the report looks at UK expenditure in more detail, with details of R&D expenditure by company size and the ratio of R&D expenditure against turnover.

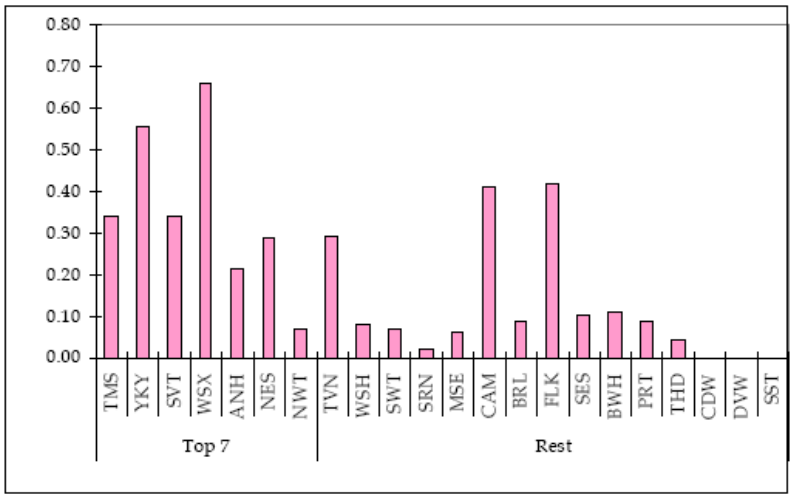
Figure 8: R&D Expenditure by company size (2008)



Source: interviews with water companies; water companies' 2003-2088 Annual Reports and 2003-2008 Regulatory Financial Statements.

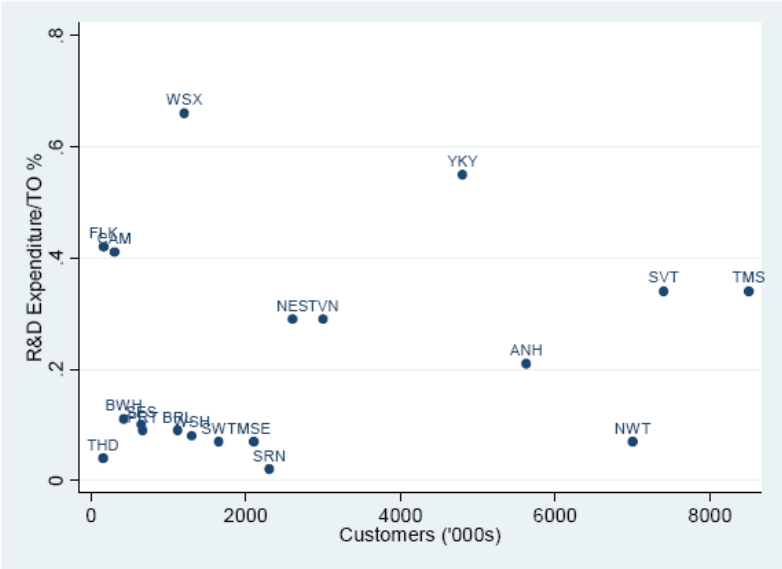
Source of chart: London Economics, DEFRA

Figure 9: Water companies R&D Expenditure/Turnover (2008)



Source of chart: London Economics, DEFRA

Figure 10: R&D Expenditure intensity by company size (2008)



Source: interviews with water companies; water companies' 2003-2088 Annual Reports and 2003-2008 Regulatory Financial Statements.

Source of chart: London Economics, DEFRA

- Total R&D expenditure does appear to display some correlation with the size of the company. It is important to ascertain if this link also holds true when taking into account a company's turnover, providing an indication as to the 'true value' a company sees in R&D, and its obligation to consumers and shareholders to innovate and compete within the market.
- Companies' "expenditure in R&D ranges from 0.02% of company turnover (SRN) to 0.66% (WSX) of turnover."
- On average the 'top 7' identified in the report spend over twice as much on R&D (average ratio 0.35) in comparison to the remaining competitors (average ratio 0.15).

Finally, when relating the R&D expenditure ratio to the customer base the following was concluded:

- "It is also worth observing that the R&D expenditure ratio does not seem to be driven by size or type of activity: four of the ten companies with largest R&D expenditure to turnover ratio are water only companies and three of them have less than 500,000 customers".

Telecommunications

- Rural investment
- Improving broadband quality and speeds
- Fibre optic network improvement
- Roll out of next generation of mobile technology

The telecommunications industry has changed significantly over the past 20 years. The development and commercialisation of the internet has resulted in a significant rise in demand for broadband services (on demand TV through to music streaming and increased usage of cloud computing). This demand has required companies to be innovative and invest significant sums in the network infrastructure.

Recent government announcements concern the roll out of such infrastructure to the more remote rural areas, as more services are opting to become entirely electronic.

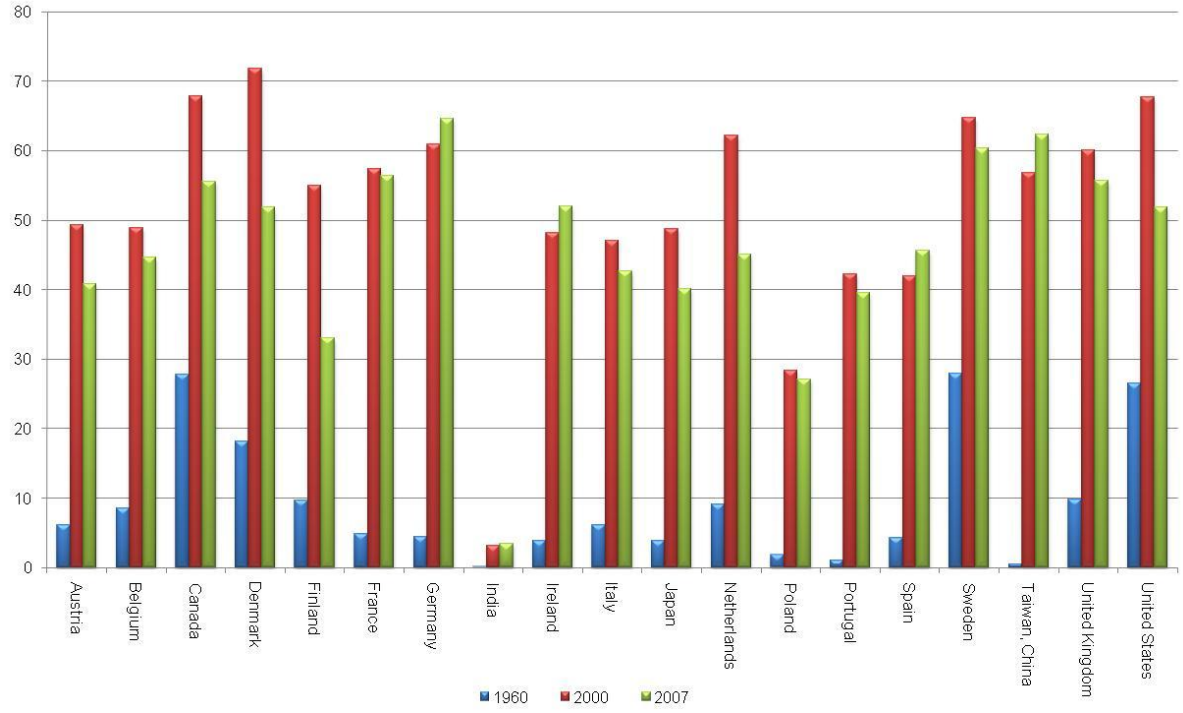
It is important not to underestimate that this technology is still in its infancy. Mobile and wireless services such as 4G and Wimax will continue to change the way in which this industry operates, offering significantly longer range and higher speeds. They may also make it to remote rural areas before fibre optic lines.

The challenge for the industry will be maintaining the pace of such investment given the tightening credit conditions and lower confidence levels of investors. If we cast our minds back to the rollout of the 3G network it was far from smooth, with mounting costs and many companies questioning the anticipated demand from consumers. No one at that time was predicting that the likes of Facebook would take the internet and mobile computing world by storm.

The telecommunications industry originally expanded using fixed lines. With mobile technologies now in use these lines are still being used to deliver high speed services. For this reason data from the United Nations[12] showing the number of fixed lines per 100 inhabitants has been included for a number of countries.

[12] Source: data, United Nations, http://www.un.org/

Main (fixed) telephone lines per 100 inhabitants



Source: Data - United Nations (UN)

Since the 1960s the expansion of telecommunications has been significant with the number of fixed lines per 100 inhabitants rising significantly, however between 2000 and 2007 few countries have seen this trend continue to rise.

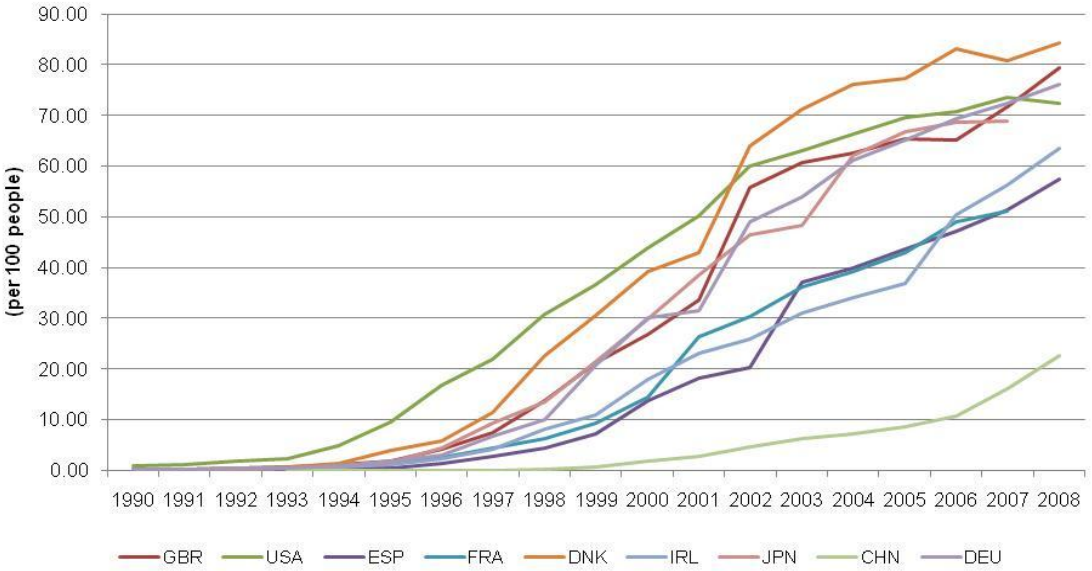
This period demonstrates the effect of the mobile telephone being utilised for a growing number of voice calls and 3G network coverage and speeds increasing to the point at which 'smart phones' become usable and so more readily available. Given that this trend seems unlikely to reverse the number of fixed lines seems set to continue declining.

Inspite of the above we are unlikely to see the demise of the fixed line just yet. TV on demand and high definition services are unlikely to be broadcast over mobile networks in the near future and if ever there were a mobile revolution, high speed fibre optics would still be required to carry signals between antenne to provide wireless services.

To illustrate just how rapidly demand has changed for technologies such as the internet and mobile phones below are two series from the World Bank[13]

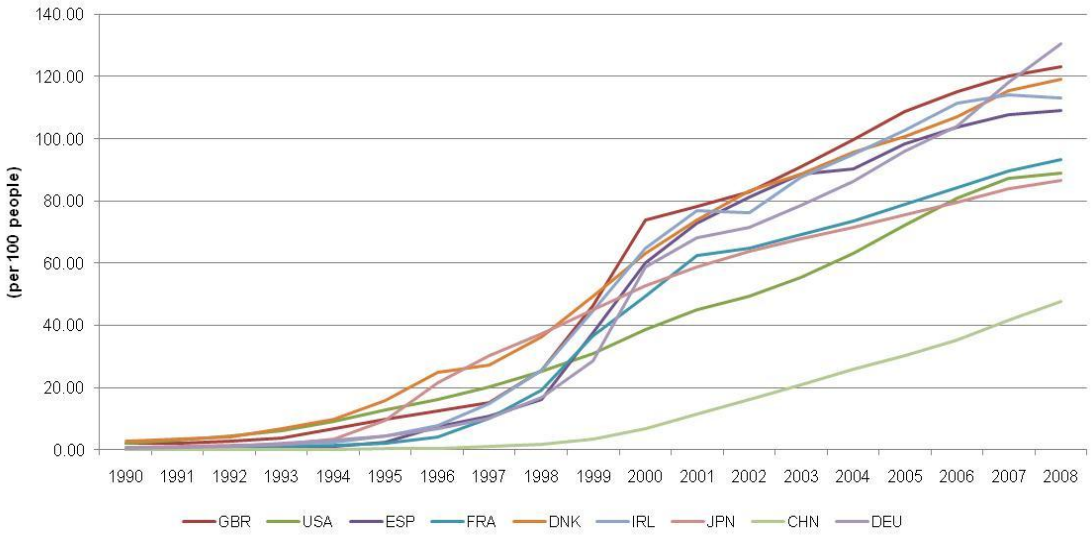
[13] Source: data, World Bank, http://www.worldbank.org/

Internet users (per 100 people)



Source: Data - World Bank

Mobile cellular subscriptions (per 100 people)



Source: Data - World Bank

The uptake in both of the above technologies has increased significantly since 1998, with UK internet users increasing from 13.68 (1998) to 79.41 (2008) per 100 people and mobile subscriptions 25.44 (1998) to 123.07 (2008) per 100 people.

Given the pace of technological change no particular emerging technologies can be ruled out. HD streaming, 3D TV, wireless internet and possibly wireless power

will all present their challenges in terms of upgrading the UK's infrastructure, exerting pressure on companies to invest and stay ahead of the competition.

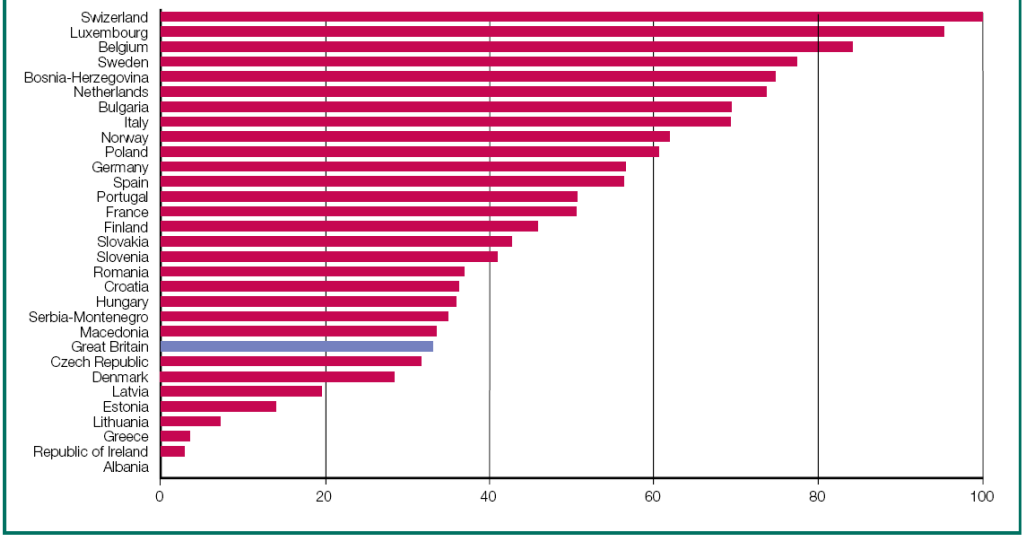
Rail

- Railway electrification
- High speed development
- Addressing investment sources and issues (network rail, franchises)
- Freight vs passenger

The railway infrastructure in the UK has been of particular interest recently, with electrification and possible expansion of high speed rail high on the political agenda. The rationale behind these projects is not just one of improving the network but also that of carbon mitigation. Electrification of the railway means that lighter more efficient rolling stock can be used instead of diesel powered locomotives, whilst high speeds rail's potential substitution effects in place of air travel make it a environmentally attractive option.

In 2009 the DFT published a report on the electrification of a substantial part of the UK network entitled "Britain's Transport Infrastructure Rail Electrification[14]".

Figure 4: Rail electrification in Europe in 2005 showing percentage of network (by route km) which is electrified



Source: UIC.

[14] Source: DFT, Britain's Transport Infrastructure Rail Electrification (July 2009) http://www.dft.gov.uk/pgr/rail/pi/rail-electrification.pdf

The chart above from the report reveals that the UK has to play 'catch up' with a lot of Europe in terms of the electrification of its railways with "the last major electrification on the existing network was that of the East Coast Main Line in the late 1980s. While further routes were considered at the time, investment was constrained and other projects were considered to be a higher priority."

Unfortunately, the UK network to some extent suffers from having one of the first large scale railway networks in the world, Victorian engineers never considered that a hundred years later we would want to operate trains in excess of 200mph along the routes and gradients that were planned for the slower trains of their time.

The only way to address such issues is by investing in the railway, improving its operation and design, to account for the challenges of the next hundred years.

The case for electrification is quite strong with the Britain's Transport Infrastructure Rail Electrification report indicating that:

- "Electrification has a central role to play in the next phase of rail modernisation. Electric trains have a number of significant advantages over diesel-powered trains. They have far lower running costs, far lower carbon emissions and offer better environmental performance; they can also increase capacity and reliability, and provide a better passenger experience."

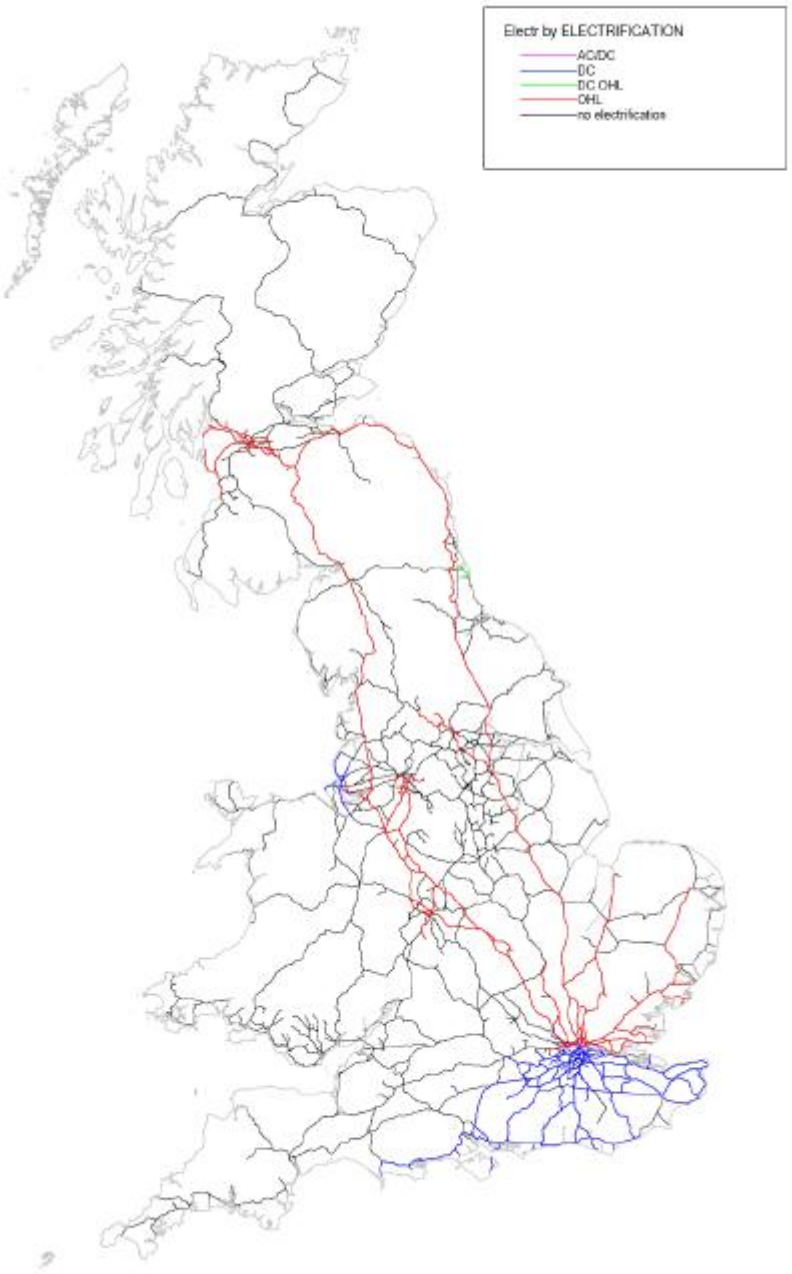
The scale of the challenge ahead should not be underestimated, and the following UK map taken from Network Rail's 2011 Network Statement[15] shows the current extent of electrification on the main rail network.

The map below also reveals the relatively restricted number of routes between the north and south of the UK. These routes are vital for connecting urban areas of economic activity and providing a viable alternative to short domestic flights.

This forms part of the rational for high speed two, with an entirely new line adding not only additional capacity but also allowing for a far quicker transfer of passengers between these economic hubs.

[15] Source: Network Rail, The 2011 Network Statement, (2010) http://www.networkrail.co.uk/aspx/3645.aspx

Extent of electrification on the main network



Source: Network Rail, The 2011 Network Statement

Government policy regarding high speed rail, its future and potential benefits can be found on the DFT website in its "High Speed Rail - Command Paper[16]". Below are some of the key messages from this paper:

[16] Source: DFT, High Speed Rail - Command Paper (March 2010)
http://www.dft.gov.uk/pgr/rail/pi/highspeedrail/commandpaper/

- "High speed rail, in contrast, delivers against every one of the Government's key objectives. It offers dramatic connectivity benefits and journey time savings between major urban centres. It provides very significant capacity increases for long-distance travellers as well as releasing space on conventional networks for increased commuter and freight services. And it achieves this whilst remaining consistent with the Government's overall strategies for reducing greenhouse gas emissions."
- "High speed rail offers benefits unmatched by any other major new infrastructure option for tackling the UK's inter-urban transport challenges over the next 20 to 30 years."
- "The modelling carried out by HS2 Ltd estimates that without a new high speed line the current 45,000 long-distance journeys taken each day on the London to the West Midlands section of the West Coast Main Line will more than double by 2033 to around 105,000."
- "The consequence of this growth will be crowded trains throughout the day and severe congestion experienced routinely during peak hours. Even with lengthened trains and other planned improvements, the West Coast Main Line will effectively be full."

Below is a copy of the comparative benefits of the possible alternatives to high speed rail:

Table 2.4 Comparative benefits of new capacity options, London to Birmingham

Comparison of London-West Midlands Corridor options	Mid-scale rail upgrade package	Large-scale rail upgrade package	New conventional Rail	New High Speed Rail	Mid-scale road package	Large-scale road package
Maximum potential capacity increase	~50%	~100%	~200%+	~200%+	~20%	~20%
Journey time improvement	~10 mins	~20 mins	~20 mins	35 mins	~2–4 mins	~3–6 mins
Present value costs to HMG (bn)	£3.1	£13.7	c. £11.5	£11.9	£1.4	£3.2
Present value benefits (bn)	£6.8	£11.6	c. £22.5	£28.7	£5.1	£7.0
Benefit:cost ratio	2.2	0.9	~2.0	2.4	3.7	2.2
Disruption impact						
	Works at Euston and Manchester Piccadilly. Grade separation and significant 4-tracking on WCML.	Works at 2 major London terminals, Birmingham Moor St. and Manchester Piccadilly. Significant 4 tracking of WCML and almost all of Chiltern Line	Major works at Euston and connection to WCML at Lichfield	Major works at Euston and connection to WCML at Lichfield	Modification of 255 motorway lane miles for Hard Shoulder Running and widening of 34 lane miles with associated temporary speed restrictions and lane closures	Widening of 448 motorway lane miles with associated temporary speed restrictions and lane closures

Source: DFT

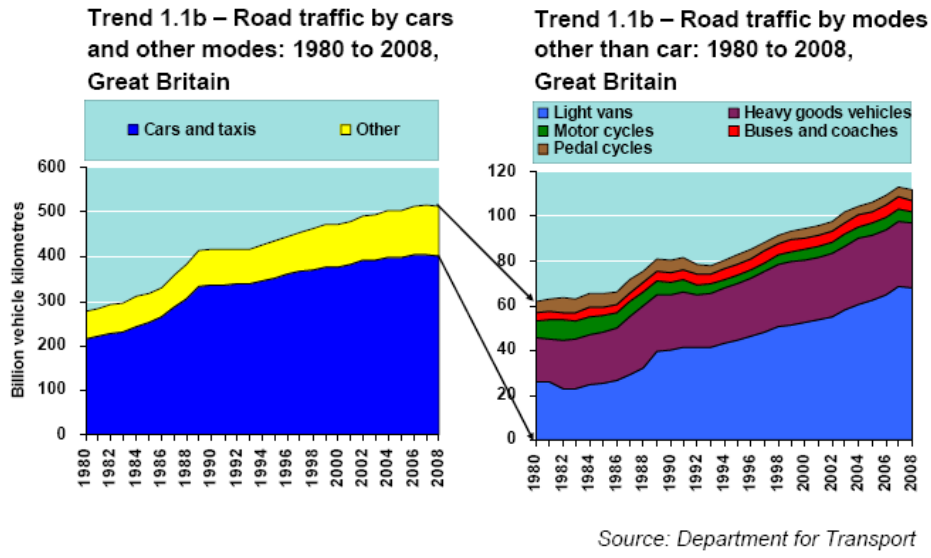
- “Furthermore, HS2 Ltd’s work suggests that a well-designed and managed high speed rail project, despite its substantial costs, could deliver high value for money, with well over £2 of benefits for every £1 spent.”
- “HS2 Ltd has estimated the present value cost of High Speed Two as around £25.5 billion at 2009 prices. “
- “If these wider economic impacts are included in the assessment the benefit:cost ratio increases to 2.7:1.”

Roads

- Investment priorities
- Local authority co-operation and co-investment
- Managed motorways – the next step
- National vs local investment
- Future proofing the network for the green era

Roads are important not only for the private car owners but also the transportation of freight and public transport. The road network has expanded significantly over the past century as have the challenges facing the industry, from reliability through speed and safety and now to carbon reduction.

The latest edition of Transport trends[17] by the DFT, shows a continuing upward trend in the levels of road traffic.



Source of chart: DFT, Transport Trends 2009 Edition

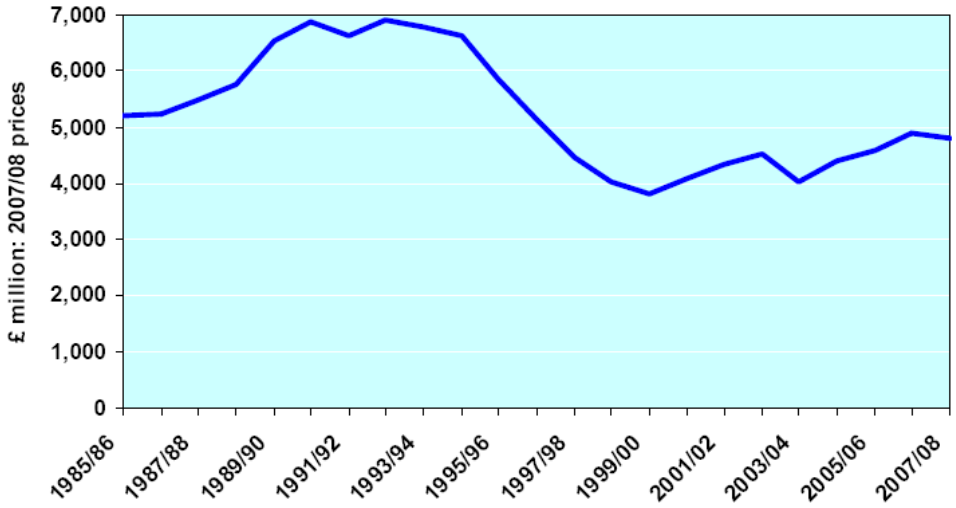
- "Total estimated road traffic increased by 85 per cent between 1980 and 2008, from 277 to 514 billion vehicle kilometres. Most of this growth occurred between 1980 and 1990; since 1990 traffic has increased by almost a quarter."

[17] Source: DFT, Transport Trends 2009 Edition, http://www.dft.gov.uk/adobepdf/162469/221412/190425/220778/trends2009.pdf

- “Between 2007 and 2008, total road traffic fell by 3.6 billion vehicle kilometres (0.7 per cent).“
- “In 2008, car traffic accounted for 78 per cent of road traffic, this proportion has remained stable since 1980.”
- “Light van traffic has increased more than two and a half times since 1980, from 26 to 68 billion vehicle kilometres. The distance travelled by heavy goods vehicles has also increased, from 20 to 29 billion vehicle kilometres, a rise of 46 per cent since 1980, but decreased by 0.6 billion vehicle kilometres between 2007 and 2008.”
- “Bus and coach traffic increased by 47 per cent between 1980 and 2008, from 3.5 to 5.2 billion vehicle kilometres. Motorcycle traffic halved between 1980 and 1995, but then increased by 37 per cent between 1995 and 2008.”

However, despite an upward trend in the number of trips that occur, investment levels in Great Britain fell substantially from a peak of £6.9bn in 1992/93 to approximately £4bn in 1999/00. Investment levels have improved since then with investment in 2007/08 standing at £4.8bn. Although not shown below it is likely that the financial crisis will result in capital projects being squeezed and investment funds being withdrawn.

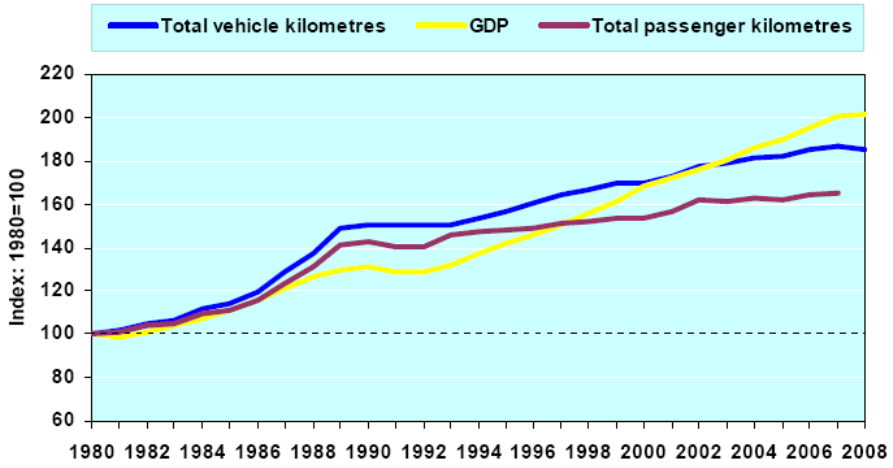
Trend 1.7b – Investment in road infrastructure: 1985/86 to 2007/08, Great Britain



Source: Compiled by Department for Transport
The data in this chart are outside the scope of National Statistics

Source of chart: DFT, Transport Trends 2009 Edition

The DFT also analyse the growth in total vehicle kilometres and its relation to GDP. It is found that although a strong correlation existed until 1994, the relationship has weakened since then with GDP growth outstripping that of total vehicle kilometres.



Source: Department for Transport and Office for National Statistics

Source of chart: DFT, Transport Trends 2009 Edition

This decoupling is likely to be occurring due to the increased efforts of government to reduce the social and environmental effects of roads. Climate change policies are beginning to alter social behaviour, travel, energy production, technology and the ways in which goods are produced.

The motoring industry will play an important part in meeting the UK's target of an 80% reduction in greenhouse gases by 2050 (based upon 1990 levels).

The "Roads – Delivering Choice and Reliability[18]" report by the DFT, outlines how the government intend to achieve the interim 2020 target of a reduction of 20%:

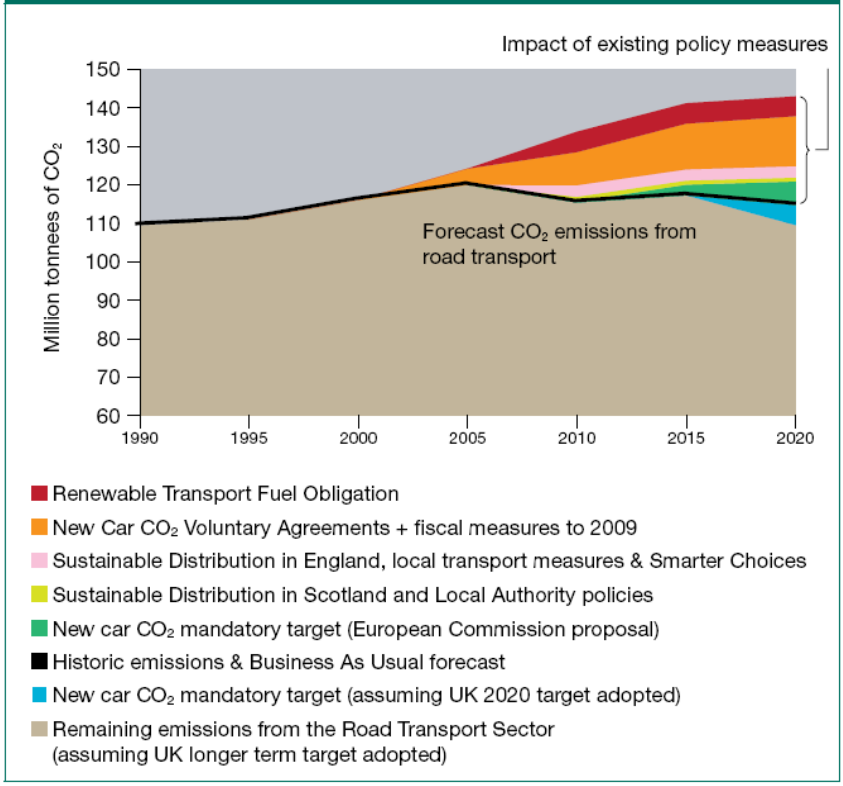
- "The government is actively "pushing for the establishment of a mandatory EU target of 100 g CO_2 per kilometre by 2020 as the average for all new cars sold, in addition to the 130 g/km target being proposed by the European Commission for 2012."
- "Developing tighter Euro standards for new vehicles and fuels is also a major lever for improving national air quality."
- "Supporting the development of lower-carbon vehicle technologies."

[18] Source: DFT, Roads – Delivering Choice and Reliability, http://www.dft.gov.uk/pgr/roads/introtoroads/roadcongestion/roadscommandpaper1.pdf

- "Beyond the development of vehicle technology, there is an important relationship between emissions and better managing capacity and traffic flow. The worst option of all – stop-start traffic and gridlock on our roads – is bad for the economy, for the environment and for our quality of life."
- Better management of the environmental effects of the lifecycle and building of infrastructure.

The reductions forecast from these measures are shown below, and demonstrate how the motoring industry will have to adapt between now and 2020.

Figure 1: Historic and forecast emissions from the road transport sector, Great Britain



Source of chart: DFT, Roads – Delivering Choice and Reliability

Although technological improvement and tighter standards will help to alleviate the environmental and social impact of the motor industry, ultimately it is investment in the production methods and infrastructure that is going to deliver significant reductions. For example:

- Life cycle and environmental improvements and regulations will require companies to innovate and militate against the effects of environmental damage. This will inevitably drive up the cost of investment as cutting edge low carbon

technologies are relatively more expensive than those that are tried and tested, and although prices will fall as these become common place, there will always be a newer more expensive and innovative replacement waiting in the wings.

- Irrespective of which technologies 'wins' the low carbon race one thing is certain the infrastructure to support it does not currently exist. If this technology is electric cars, we do not have sufficient capacity, charging stations or clean generation to meet such demands and if hydrogen power shines through cleaner production methods and the refitting of all existing refuelling facilities will have to take place.

Technological progress is also interesting in that the 'low carbon, high safety vehicle' of the future may re-couple the link between GDP and motor growth as the environmental and social externalities of using vehicles falls, and the convenience of private point to point transport remains. This scenario would result in rising demand for improvements and further expansion of the UK's roads network.

This highlights the potential importance of investment not only in terms of economic returns, social or environmental benefits but also as a method of securing long term stability.

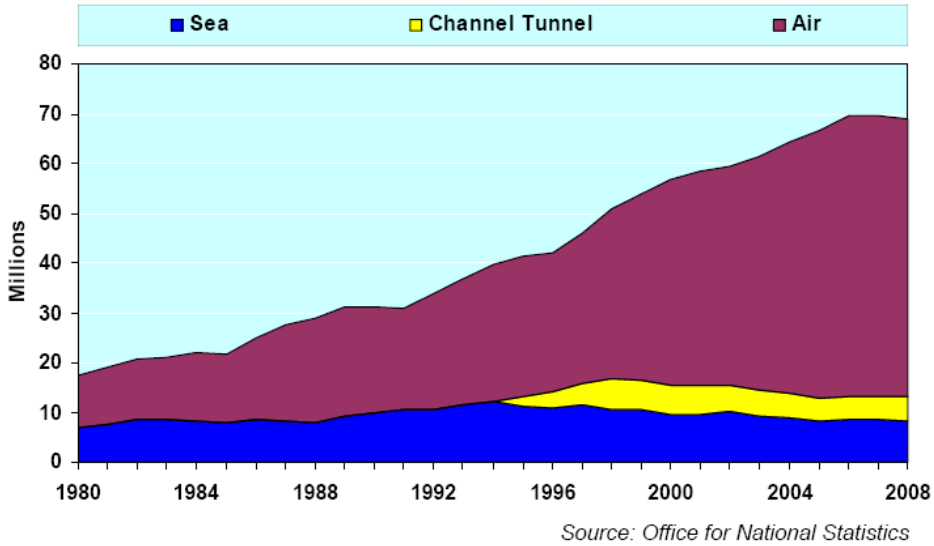
Air and maritime

- Environmental standards, targets and opportunities
- Maintaining security
- Connections to existing infrastructure
- Freight transport

The aviation and maritime industries have experience rapid growth over the past century as globalisation and technology has enabled more efficient and effective methods concerning the movement of goods and people. Such growth has created challenges in terms of securing national boarders, the integration of transportation with existing infrastructure and more recently the environmental impacts of long haul transportation. To understand fully the impact of the growth within the aviation and maritime sectors it is important to understand how their utilisation has changed.

The DFT transport trends 2009 Edition provides information on the visits made to the UK (12 million 1980 – 32 million 2008) and UK residents visits abroad (18 million 1980 - 69 million in 2008) both of which have increased substantially. The growth in the aviation industry and the reduction of air fares has contributed substantially to this growth.

Trend 6.3a – UK residents' visits abroad by mode: 1980 to 2008, United Kingdom

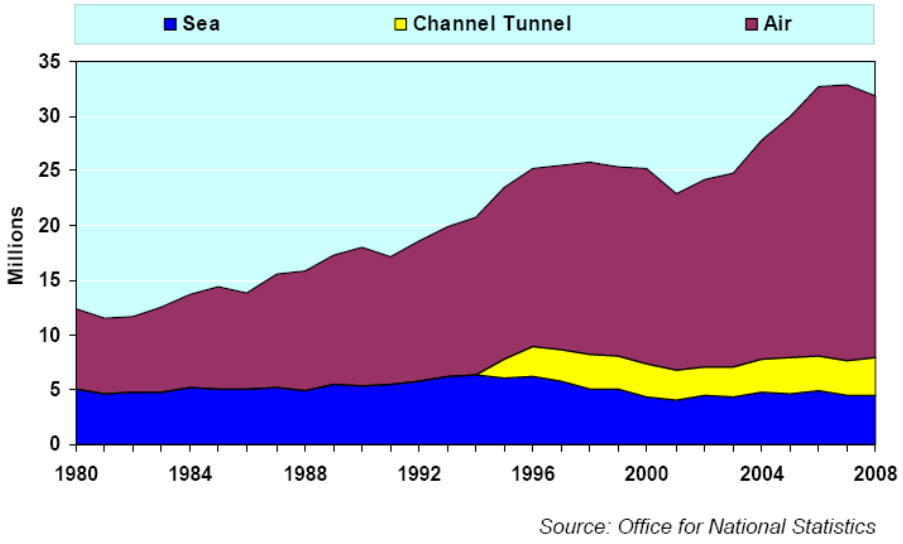


Source of chart: DFT

UK resident visits abroad:

- “In 2008, 81 per cent of UK residents' trips abroad were by air, 12 per cent by sea and 7 per cent by the Channel Tunnel.”
- “Sea trips had increased from 1980 to 1994 from 6.8 million to 12.0 million. However, there were falls in sea trips from 1997 partly as the Channel Tunnel replaced trips previously undertaken by ferry and partly as more people travelled abroad by air.”

Trend 6.3b – Overseas residents’ visits to the UK by mode: 1980 to 2007, United Kingdom



Source of chart: DFT

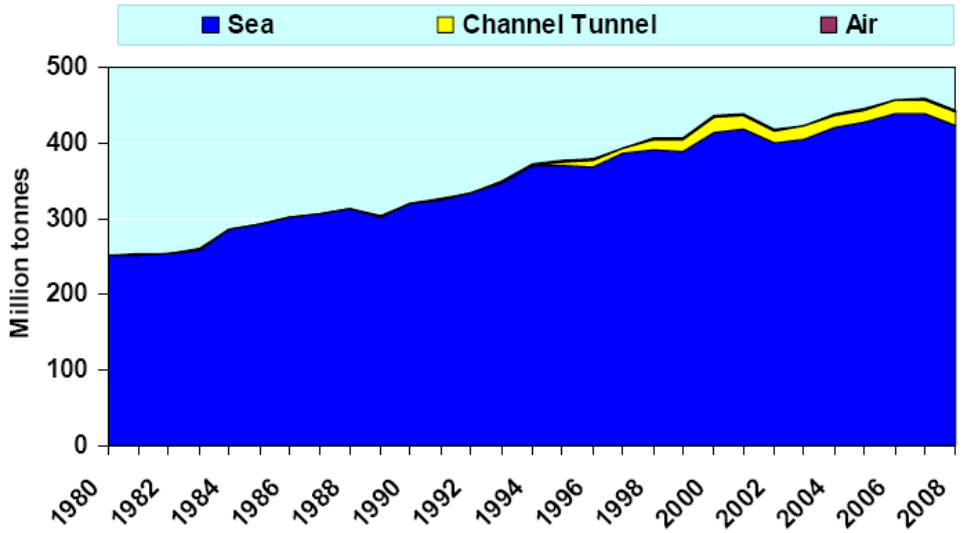
Visits to the UK from overseas residents

- “In 2008, 75 per cent of overseas residents' visits to the UK were by air. Sea travel now makes up just 14 per cent of overseas trips to the UK, compared with 41 per cent in 1980. The Channel Tunnel accounted for 11 per cent of overseas residents’ trips to the UK in 2008.“

Freight is also an important aspect of international trade, and when looking at UK international freight movements the volume carried by air is small compared to that of the maritime industry. Although passenger numbers have tailed off since 1996 (above) freight traffic has continued to increase with the exception of the 2007-2008 period (below).

- "Waterborne freight dominates UK international trade. In 2008, 95 per cent of tonnage lifted was by sea, 4 per cent by Channel Tunnel and around a half of 1 per cent by air."

Trend 5.9 – UK International freight lifted: 1980 to 2008, United Kingdom



Source: Department for Transport (sea and Channel Tunnel) and the Civil Aviation Authority (air)
The Channel Tunnel and Air data in this chart are outside the scope of National Statistics

Source of chart: DFT

The DFT "Transport Statistics Report Maritime Statistics 2008[19]" provides further details on the current trends and conditions within the maritime sector.

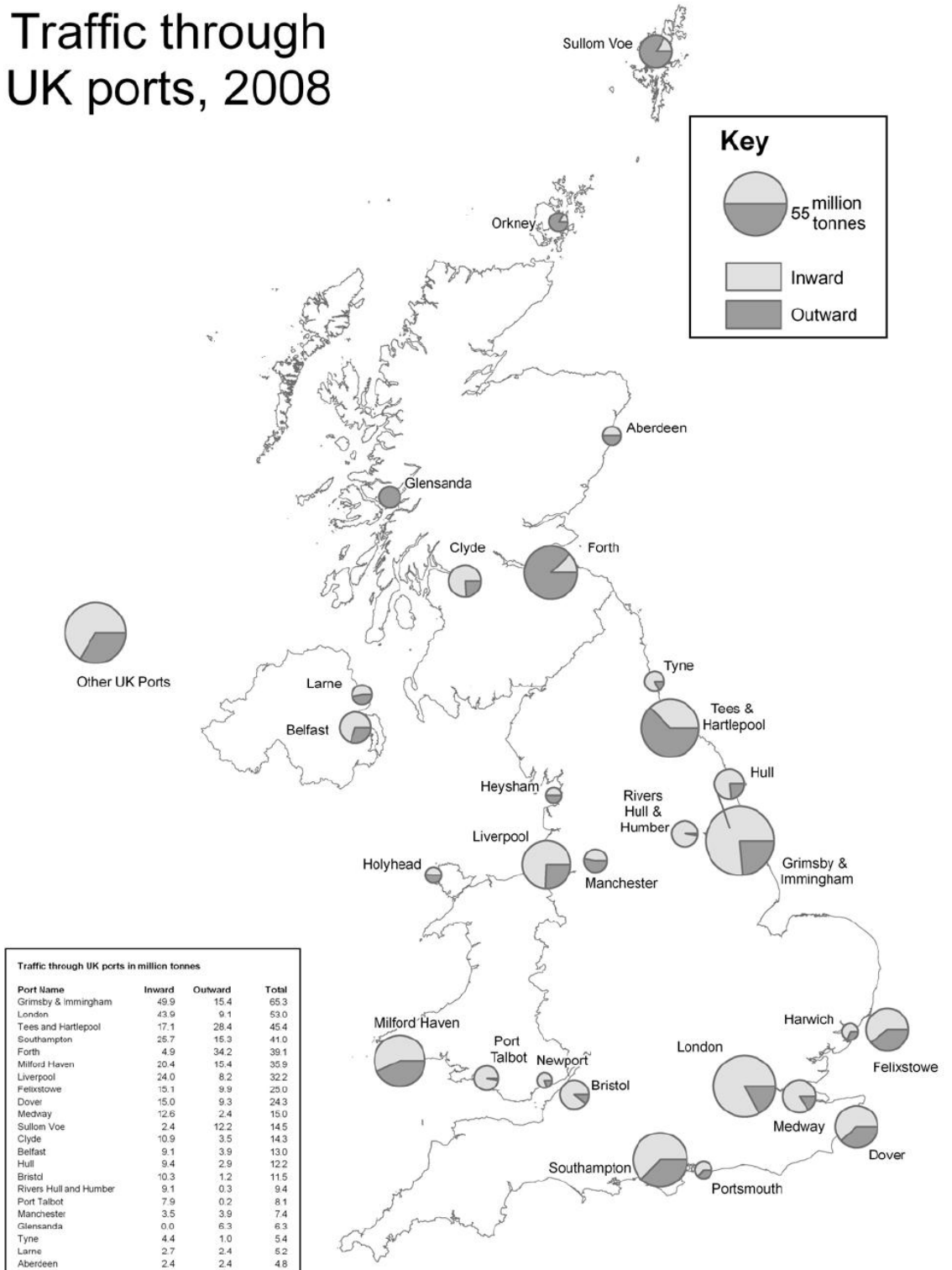
In terms of infrastructure the distribution and tonnage/usage of its main ports in the UK the report found that the leading ports by tonnage in 2008 are as follows:

- Grimsby & Immingham - 65.3Mt
- London - 53.0Mt
- Tees & Hartlepool - 45.4Mt
- Southampton - 41.0Mt
- Forth - 39.1Mt

Alternatively, the traffic through the UK ports in 2008 is shown graphically on the next page:

[19] Source: DFT, Transport Statistics Report Maritime Statistics 2008, http://www.dft.gov.uk/adobepdf/162469/221412/221658/223721/4082361/maritimestatistics2008.pdf

Traffic through UK ports, 2008



Traffic through UK ports in million tonnes

Port Name	Inward	Outward	Total
Grimsby & Immingham	49.9	15.4	65.3
London	43.9	9.1	53.0
Tees and Hartlepool	17.1	28.4	45.4
Southampton	25.7	15.3	41.0
Forth	4.9	34.2	39.1
Milford Haven	20.4	15.4	35.9
Liverpool	24.0	8.2	32.2
Felixstowe	15.1	9.9	25.0
Dover	15.0	9.3	24.3
Medway	12.6	2.4	15.0
Sullom Voe	2.4	12.2	14.5
Clyde	10.9	3.5	14.3
Belfast	9.1	3.9	13.0
Hull	9.4	2.9	12.2
Bristol	10.3	1.2	11.5
Rivers Hull and Humber	9.1	0.3	9.4
Port Talbot	7.9	0.2	8.1
Manchester	3.5	3.9	7.4
Glensanda	0.0	6.3	6.3
Tyne	4.4	1.0	5.4
Larne	2.7	2.4	5.2
Aberdeen	2.4	2.4	4.8
Orkney	0.6	4.0	4.6
Portsmouth	2.5	1.5	3.9
Harwich	2.5	1.2	3.7
Holyhead	1.7	1.7	3.4
Newport	2.6	0.6	3.2
Heysham	1.6	1.6	3.2
Other UK ports	34.1	17.3	51.4
Total UK Ports	346.5	215.7	562.2

Source of chart: DFT

Within the report there is also a breakdown of the different types of freight that pass through the UK's ports.

- "Liquid bulk is by tonnage the largest cargo handled at major ports, totaling 239 million tonnes (44 per cent of total traffic) in 2008. The major constituents, crude oil and oil products, totaled 132 million and 87 million tonnes. Crude oil traffic has fallen by 28 per cent since 2000."
- "Dry bulk movements totalled 125 million tonnes (23 per cent of total traffic) in 2008. Movements of coal, the largest constituent of dry bulk, have increased by 82 per cent since 2000."

Review of literature

Economic Papers

OECD Infrastructure investment – Links to growth and the role of public policy[20]

The OECD paper produced by Égert, B. T. Kozluk and D. Sutherland (2009), uses available data to ascertain the potential effects of infrastructure investment and the subsequent impact and implications this has on public policy.

Trends identified within the paper

- "The contribution of network industries to an economy particularly with respect to investment where it is mentioned they account for between one tenth and one quarter of economy wide investment."
- Investment rates have generally been falling in OECD countries over the past two decades (energy water and transport).
- Telecommunications investment on the other hand has seen substantial levels of investment.
- While the physical level of infrastructure may have increased it is important to realise that this may not have kept pace with the rate of output growth.
- Congestion has become an area of concern in many types of transport and the energy sector.

Investment and growth

- "The impact of infrastructure on output is difficult to pin down and the direction of causality hard to determine empirically. However, there is some evidence, from annual and multi-year growth regressions, that investment has positive effects that go beyond the impact to be expected from a larger capital stock."
- "Furthermore, infrastructure investment appears to have a nonlinear effect with on average a stronger long-term effect on growth at lower levels of provision. At the same time, these effects are not commonly shared across OECD

[20] Source: Égert, B., T. Kozluk and D. Sutherland (2009), "Infrastructure Investment: Links to Growth and the Role of Public Policies", *OECD Economics Department Working Papers*, No. 686, OECD Publishing. doi: 10.1787/225678178357

economies, where there is some evidence suggesting episodes of both under- and over-provision and of both efficient and inefficient use of investment."

Policy implications

- "Before undertaking investment in new capacity, it is important to ensure that best use is made of existing infrastructure. User fees and congestion charges can play a key role in ensuring efficient use of scarce infrastructure and also give more accurate signals of where additional capacity may be warranted. Curbing anti-competitive practices of incumbent infrastructure operators can also increase effective availability of capacity."
- "Incentive regulation, such as setting price caps for infrastructure services, can help ensure that investment is cost reducing and mimics a competitive environment. Independence and accountability of the sectoral regulators can help establish a stable and credible framework for infrastructure investment. Empirically, there is evidence that price-cap regulation when combined with regulatory independence boosts investment, especially in electricity and telecommunications."
- "A competitive environment is generally supportive of more efficient use of resources and there is evidence that removing barriers to entry – such as requiring vertical unbundling and establishing regulated third part access regimes – can foster higher rates of investment in the network industries."
- "Due to the potential widespread benefits, scale and/or side-effects (such as environmental) of infrastructure investment, governments often need to determine whether more private sector infrastructure investment is justified. In this context, national plans for investment – which a number of governments report having – can help frame infrastructure objectives."

When utilising mechanisms such as public-private partnerships (PPPs) it is important that the following occur:

- "The decision making about the use of concessions and PPPs should be transparent to ensure that they are the most appropriate method of investment."

- "Contract specification should share risk appropriately between the parties and investment incentive mechanisms should be specified throughout the concession period."
- "Monitoring of investment decisions and performance evaluation throughout the contract period are important to guarantee value for money."

Regression estimations

Table 1. Annual time-series growth regressions

Using Dynamic OLS

Panel A. Transport infrastructure - total length per capita

	Roads		Rail		Motorways	
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
			Long run (mean group)			
Investment	0.46 **	0.3 *	0.53 ***	0.39 **	0.42 ***	0.4 ***
Population growth	0.032	0.019	0.013	-0.007	0.019	-0.005
Human capital		0.18		0.08		-0.03
trend	0.02 ***	-0.03	0.03 ***	-0.08	0.02 ***	-0.11
			Country specific long run coefficients for infrastructure			
Australia	0.17	0.07	0.46 ***	0.50 ***		
Austria	-0.13	0.07	2.27 ***	1.04 ***	0.30 ***	0.17 ***
Belgium	0.27	0.12	-1.01 ***	-0.39 **	0.18 ***	0.12
Canada			0.45	3.02		
Denmark	1.19 *	-0.75	-0.20 ***	-0.11	0.15 ***	0.10
Finland	1.66	-0.32	0.29	-0.48	0.01	0.00
France	-0.81 ***	-0.52 ***	-2.52 ***	2.21 **	0.14 ***	0.09
Greece	-0.09 ***	-0.09 **	2.22 ***	0.93 ***		
Iceland	-1.45 ***					
Ireland	-2.29 ***	0.83	2.02 ***	0.03	0.00	0.00
Italy	-0.28 ***	-0.04	-0.94 ***	-0.45	0.17 ***	0.06
Japan	0.64	1.43	2.46 ***	0.28	0.17 ***	0.13 ***
Korea	0.17		1.06 ***			
Mexico	0.17 *					
Netherlands	-0.45 *	-0.75 ***	-0.15	-0.91 ***	0.12 **	1.00 ***
New Zealand	1.85 ***	2.51 ***	0.95 ***	1.45 ***	-0.34 ***	0.05
Norway	0.75 *	1.21	-1.37 *	-0.13		
Portugal	0.30 ***	-0.04	0.09	-0.44 ***	-0.16 ***	0.00
Spain	-0.43 *	-0.48 **	-1.28 ***	-1.95 ***	0.17 ***	0.16 ***
Sweden	-0.14	-0.35	-0.22	-0.21	0.23 ***	0.16
Switzerland	-0.55 *	-0.59	-3.65 **	0.70	0.08	0.11
Turkey	-0.13		-0.83			
United Kingdom	0.92 **	1.20 ***	0.30 **	0.80 ***	-0.02	-0.12
United States	1.86	2.00	-0.07	1.31 ***	-0.10	-0.47
			Short run (mean group)			
Error correction term (-1)	-0.26	-0.39	-0.25	-0.53 *	-0.4	-0.56
Adjusted R-squared long run	0.994	0.995	0.993	0.995	0.995	0.996
Adjusted R-squared short run	0.4	0.42	0.4	0.45	0.46	0.47
F-test	5.18	4.34	5.38	5.5	5.67	5.96
Durbin Watson statistic	1.47	1.68	1.55	1.74	1.75	1.82
Number of observations	849	615	845	666	600	529

Note: The top panel gives the mean-group coefficients for the long run as well as the country-specific long-run coefficients for the infrastructure variable; the intermediate panel gives the coefficients for the short-run error correction term; the bottom panel gives regression diagnostics; ***, **, * denote the 1%, 5% and 10% level of significance, respectively; heterogenous coefficients were used as the Wald test on homogenous coefficients was rejected for each regressor variable individually and for all regressors jointly.

The coefficient of the infrastructure stock should be interpreted as the effect in addition to the effect of just adding to the productive capital stock. In this sense, a positive (negative) coefficient implies that the impact on output would be higher (lower).

Source: OECD

Table 1. [Cont]

Using Dynamic OLS

Panel B. Electricity and telecommunications infrastructure

	Electricity		Telephone mainlines		Telephone subscriptions	
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
			Long run (mean-group)			
Investment	0.39 ***	0.39 ***	0.39 ***	0.42 ***	0.45 ***	0.34 **
Population growth	0.004	-0.006	0.021	0.003	0.024	0.009
Human capital		0.08		0.15		0.68
trend	0.02 ***	-0.11	0.02 ***	-0.13	0.02 ***	-0.07
			Country specific long run coefficients for infrastructure			
Australia	-0.04	-0.23 **	-0.46 ***	-0.43 ***	0.26	0.41 ***
Austria	0.40 ***	0.24 ***	0.39 ***	0.21 ***	0.71 ***	0.18
Belgium	0.54 ***	0.22 ***	0.37 **	-0.08	-0.70 ***	-0.24 *
Canada	0.04	-0.08	0.02	0.01	0.02	0.56
Denmark	0.26 ***	0.36 **	0.21 *	-0.14	0.25	0.22
Finland	0.00	-0.04	-0.03	-0.03	1.03	0.98
France	0.31 ***	0.15 **	0.10 ***	0.01	-0.26 ***	-0.11 *
Greece	0.31 ***	0.38 ***	0.32 ***	0.34 ***	0.16 ***	0.28 ***
Iceland	0.25 ***		-0.60 ***		0.29 ***	
Ireland	-0.40 ***	-0.40 ***	-0.56 ***	-0.19	-1.19 ***	-0.05
Italy	1.15 ***	1.13 ***	0.42 ***	0.32 ***	-0.14 ***	-0.11
Japan	0.54 ***	0.40 **	0.33 ***	0.12	-0.25 ***	-0.13 ***
Korea	-0.23 ***		0.02		0.03	
Mexico	0.58 ***		0.68 ***		0.87 ***	
Netherlands	0.25 ***	0.21	-0.12 *	0.00	-0.31 ***	-0.75 ***
New Zealand	-0.28 ***	-0.29 **	-0.80 ***	-1.06 ***	0.18 ***	0.11 ***
Norway	0.14 ***	0.34	0.10	0.13 **	-0.19	-0.34 *
Portugal	0.26 ***	-0.04	0.31 ***	0.07	-0.30 ***	-0.26 ***
Spain	0.35 ***	0.37 ***	0.19	0.64 ***	-0.57 ***	-0.75 ***
Sweden	0.03	-0.01	-0.11	-0.02	-0.01	0.14
Switzerland	0.08	-0.16	0.13	-0.32	-0.04	0.03
Turkey	0.26 ***		0.08		0.28 **	
United Kingdom	0.09	0.49 ***	-0.21 ***	-0.29 ***	-0.39 ***	0.64 ***
United States	-0.08 *	-0.18	0.55 *	0.24	0.31 **	0.47
			Short run (mean group)			
Error correction term (-1)	-0.24	-0.41	-0.24	-0.49	-0.35	-0.58
Adjusted R-squared long run	0.996	0.996	0.996	0.996	0.997	0.998
Adjusted R-squared short run	0.43	0.41	0.45	0.45	0.42	0.45
F-test	4.85	5.1	6.58	5.74	5.53	3.75
Durbin Watson statistic	1.55	1.69	1.63	1.7	1.5	1.64
Number of observations	961	700	958	697	912	669

Note: The top panel gives the mean-group coefficients for the long run as well as the country-specific long-run coefficients for the infrastructure variable; the intermediate panel gives the coefficients for the short-run error correction term; the bottom panel gives regression diagnostics; ***, **, * denote the 1%, 5% and 10% level of significance, respectively; heterogenous coefficients were used as the Wald test on homogenous coefficients was rejected for each regressor variable individually and for all regressors jointly.

The coefficient of the infrastructure stock should be interpreted as the effect in addition to the effect of just adding to the productive capital stock. In this sense, a positive (negative) coefficient implies that the impact on output would be higher (lower).

Source: OECD

Analysis of results

In the above two scenarios have been run, the difference being that the second includes a human capital variable “as an additional, separate production input”. For further information regarding the methodology behind the model please refer to the OECD paper in which more detail is included. The effects of infrastructure investment vary between industry and country significantly.

Within the UK investment in the roads, rail and electricity sectors would all result in positive effects greater than that of the initial investment. Motorways, on the other hand, would result in a slightly negative return, as would investment in telephone mainlines. There are some possible explanations as to why negative coefficients have been calculated on the effects of motorways and telephone mainline investment.

Telephone mainlines, although important to our current lifestyle, are increasingly in competition with a wider range of newer mobile and wireless technologies. The paper recognises this as an issue and therefore also looks at telephone subscriptions regression results, it can be noted that under these conditions one of the coefficients becomes positive. This would seem to suggest that the regression is not an accurate reflection of the 'whole' telecommunications sector which encompass such technologies and so may be underestimating the benefits that an economy would undergo as investment took place in the newer mobile and wireless sectors.

Economic Benefits of Investment in Transport Infrastructure[21]

The above paper looks in more detail at the effects, modelling and the impact of the inclusion of 'wider economic benefits' within transport infrastructure appraisals. The overall conclusion of the paper is that the economic effects of infrastructure still remain uncertain however it does provide a usefull insight into the mechanisms by which spatial economics are considered and how improvements in these models should result in their utilisation in the future as part of the appraisal process within infrastructure projects.

The paper defines spillover effects as:

- "A positive spillover occurs when other agents' actions confer benefits on an individual while the individual does not provide any compensation for these benefits."

The paper reviews a wide variety of information and research as to how spatial effects occur with both positive and negative effect. Below is a summary of some of the mechanisms mentioned within the paper (please refer to original paper for source material):

- The improvement of infrastructure in one region can also confer benefits on neighbouring regions which could ultimately draw away the most productive resources with detrimental effect to the region which undertook the initial infrastructure investment.
- Improving infrastructure such as airports does not necessarily only affect routes operating through the place of improvement, but actually may reduce congestion within the whole system creating significant benefits regarding travel times and productivity.
- The potential benefits to the airport/transport system as a whole was found to be just as important in smaller airports as those of international hubs.
- Road spatial effects are much harder to model given that the direction and magnitude of networks is more extensive. Neighbour benefits are also harder to asses given that it is harder to define where benefits occur given that parties

[21] Source: J.P. Cohen, (2007), OECD, International Transport Forum, Joint Transport Research Centre, Economic Benefits of Investment in Transport Infrastructure, Discussion paper No 2007-13

can benefit from varying productivity and time improvements in a number of locations.

- The elasticities between regions vary, with some placing more emphasis on the importance of inter state infrastructure whilst other locations place more importance on cross boarder projects.
- The improvement of port infrastructure does have a beneficial effect upon variable costs within the area but was found to rise variable costs in neighbouring ports.

The effect of infrastructure on long run economic growth[22]

This paper looks at the long run consequences of infrastructure provision on GDP per capita using data from the period 1950-1992. Although it does not concentrate on individual countries it should provide a wider economic picture as to the provision of infrastructure investment and its subsequent effects upon growth. It is also important to mention that the paper was only intended to define the directional outcome/link with regards to the effect of investment spending on GDP and not its magnitude. The model also only accurately represents investments whereby the degree of the investment would not fundamentally change the investment model and so not adversely change the conditions under which the optimum level of investment is calculated.

It is found that there are links between economic growth and infrastructure investment in both the short and long run. These effects were also found to be bi-directional, meaning that changes in GDP per capita result in changes in the level of infrastructure spending required and vice versa.

It is found that:

- "Most importantly, we find evidence of a long run impact of infrastructure on GDP per capita."
- "For telephones and paved roads, the sign of the effect of an increase in provision on GDP per capita varies across countries, being positive in some but negative in others." Investment in such infrastructure and its effect on GDP will ultimately be decided depending upon whether your economy is currently considered to be above or below the optimum level of provision.
- "This suggests that the long run effects of increased provision of telephones and paved roads on growth are close to zero ***on average*** across countries, but that there are significant nonzero long run effects in individual countries."
- The "long run effects of investment in electricity generating capacity are positive in a large number of countries, with negative effects being found in only a few."

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22 D.Canning and P. Pedroni (2004), The effect of infrastructure on long run economic growth, http://www.williams.edu/Economics/wp/pedroniinfrastructure.pdf

- However in the conclusion of the paper it is stated that “for electricity generating capacity our results can be taken to support the view that countries are all close to the optimal level of provision, though we do have some evidence of under provision in some countries.”

The paper paints a picture of the provision of infrastructure being around the optimum level across the countries included within the study: “In some ways our results are not surprising. If infrastructure were provided in competitive markets, and there were no externalities present, this optimality result would be exactly what we would expect. However, in practice, infrastructure has often been supplied by the public sector, and we have the possibility of large externalities, perhaps leading to misallocation of resources.”

This would appear to suggest that the public sector is doing a relatively good job in the provision of infrastructure on average over the countries included in the study. However, as mentioned above, there are variances between countries which subsequently are above or below their optimum level of provision. So although on average infrastructure needs are being met across the nations there is still the case that the misallocation of resources is occurring on a national level. It could be argued that if the provision of infrastructure occurred via private mechanisms that this misallocation at the national level may be less likely to occur.

Broadband Infrastructure and Economic Growth[23]

The recent interest by government to improve the broadband infrastructure of the UK has been widely publicised. This is an issue that not only affects the UK and could still significantly change the manner in which business transactions occur over then next 20 years. This should in theory improve labour productivity and open up competition between markets, which will subsequently encourage innovation and efficiency impacting upon economic growth. For this reason we are reviewing a paper that concentrates on broadband infrastructure and its effects and links to economic growth.

Within the paper introduction the benefits of both voice telephony and broadband are explained in the following:

- "Voice-telephony infrastructure has a coordination function and reduces transaction costs for existing businesses. On top of that, high-speed internet via broadband infrastructure may accelerate the distribution of ideas and information and foster competition for and development of new products, processes, and business models, thereby further facilitating macroeconomic growth."

When examining broadband growth and penetration the paper identifies that the roll out of broadband has occurred over the existing voice-telephony and cable TV networks. For this reason it the paper assumes that there is a "ceiling of the broadband diffusion curve across" the countries examined which is "determined by the extent of the pre-existing traditional networks."

- "Using only the part of the variation in broadband penetration that can be predicted by this diffusion model, we find a significant positive effect of broadband introduction and penetration on economic growth. Our instrumental-variable results suggest that a 10 percentage-point increase in the broadband penetration rate results in a 0.9-1.5 percentage-point increase in annual per-capita growth."

The above is very positive, and suggests that countries have benefited significantly form the development of broadband infrastructure. However, there are problems

[23] Source: N. Czernich, O. Falck, T. Kretschmer, L. Woessmann, (2009) Broadband Infrastructure and Economic Growth, CESifo Working Paper No. 2861

with the above model and its assumptions. The case is presented that existing models may not have accounted for the possibility that causality may in fact occur in the reverse direction or that omitted variables may be distorting the regressional analysis. Three examples are provided in the paper, which in summary are:

- Individuals in high wealth countries subsequently have higher disposable incomes which cold have fuelled demand for broadband.
- State intervention within a country may depend upon the level of economic activity and this subsequently would affect infrastructure investment decisions
- Finally, that technological change in broadband is linked to other technologies developing at a similar pace and so isolating individual effects is difficult.

Nina, Oliver, Tobias and Ludger (2009) attempt to overcome these issues by developing and "Instrumental-variable (IV) approach based on the fact that broadband deployment takes place alongside existing infrastructure elements, which creates path dependencies given the pre-existing heterogeneity in infrastructure across countries."

The results from the above model were:

- The "IV results show that GDP per capita is about 2.7 to 3.9 percent higher on average after than before broadband introduction, controlling for country and year fixed effects."

Subsequently a "second-stage model [is run which] specifies a classical cross-country growth model where the broadband *penetration rate* is added as a determinant of the growth rate of GDP per capita."

- The results from this second stage model show that "an increase in the broadband penetration rate by 10 percentage points increases annual per-capita GDP growth by 0.9 to 1.5 percentage points over our sample period."

The paper mentions some limitations with the model, which are that their measure of broadband was 'rough' given that the broadband classification was any connection above 256Kbit/s, and also there are limitations in prediciting the effect of technologies such as mobile broadband which may reduce the need in the future for fixed line solutions.

In summary the paper does find there to be a positive effect on GDP per capita, from the introduction and investment in broadband infrastructure. The results

above suggests that since the introduction of broadband the OECD countries have benefited from between 2.7 to 3.9 percent higher GDP per capita than if broadband introduction had not occurred.

Looking forward, the second stage model indicated that if an OECD country was to increase its penetration rate by 10 percentage points, annual GDP per capita growth can be expected to be between 0.9 and 1.5 percent higher.

Infrastructure and growth in the European Union: An empirical analysis at the regional level in a spatial framework[24]

This paper analyses the links between economic performance and infrastructure across the EU at the NUTS2 level (please see appendix F for the UK NUTS2 regional breakdown). Assessing the effects of different types of infrastructure at a regional level across the EU.

This has been included in this study as it demonstrates the importance of infrastructure on a international level. As the European Unions economies continue to integrate there is going to be wider scope for harmonisation and integration, ultimately moving towards EU regional infrastructure.

This has substantial implications for the potential effects of infrastructure upon economic growth. As the mechanisms which transfer economic conditions increasingly integrate allowing productivity transfers, it may be the case that investment within a domestic market does not only result in spatial effects within the host market. The effects of such investment would be transferred through a complex economic mechanism (in a timely manner) improving international conditions and promoting growth in a variety of markets.

The above has further implications for the appraisal and evaluation process that occurs when considering the 'economic benefit' of infrastructure projects:

- "Accurately measuring infrastructure returns is crucial from a policy perspective since the level of estimated returns should be the first guide in deciding how to allocate funds among different programs, while social cost-benefit analysis will be more appropriate for policy evaluation."
- "When considering the rate of return of infrastructure, the main problem is given by the fact that infrastructure economics has the features of imperfect markets: market failures, political objectives and constraints, regulatory and distributional issues move the returns of investment in infrastructure away from the market signals given for them."

[24] C. Del Bo, M. Florio (2008), Infrastructure and growth in the European Union: An empirical analysis at the regional level in a spatial framework, Universita Degli Studi Di Milano, Working Paper n. 2008-37

Del Bo and Florio (2008) build a series of models the first of which "considers a simple Cobb Douglas production function, with capital and labour as the only production factors."

The data displayed constant returns to scale, meaning that any change in the input functions of capital and labour would result in an equal return in GDP (the sum of labour and capital components is close to one). The paper then explores the role infrastructure would play when developing the model further, with infrastructure defined in the three following ways:

- "[Transportation/Land-Use Connections] TLC infrastructure: number of fixed phone lines and mobile subscriptions, households with internet and firms with website."
- "Indirect infrastructure: accessibility indicators such as multi-modal potential access and time to market."
- "Direct infrastructure: transport infrastructure, measured in km over square area, such as length of roads (motorways, regular roads) and railways."

Two models are subsequently produced the first combines the three measures of infrastructure to give an overall proxy; the second explores each of the above areas individually. Below are some of the conclusions reached:

Combined model

Some of the key findings are summarised below:

- "The infrastructure component helps in explaining a significant percentage of total output variance. Under this specification, labor elasticity is around 20%, capital elasticity approximately 10%, human capital 45%, and our indicator of infrastructure availability along the three dimensions specified (TLC, soft and hard infrastructure) is around 15%."

Separated Model

Some of the key findings are summarised below:

- The TLC measure shows that all of its components (fixed, mobile phones and households with internet access, and firms with website) are positive and statistically significant. Mobile phones (0.44) and firms with website (0.43) were shown to have the highest returns on GDP within the model when compared to fixed lines (0.24) and HH with internet access (0.25).

- The soft measures of infrastructure, potential accessibility (0.30) and time to market (-0.48) are also both significant with regards to their effect upon regional GDP.
- Finally the findings for traditional forms of infrastructure had varied results with motorways (0.035) and railways (0.045) reported as significant and contributing positively to regional growth. This is in contrast to the reported result for other roads (-0.037) which contributed negatively to regional GDP growth.

The above would appear to suggest that, in terms of other roads, Europe on a regional level has transport infrastructure that is operating slightly above the markets optimum provision. However, it is interesting that when Del Bo and Florio (2008) add in a congestion measure for motorways their positive effect rises from 0.035 to 0.071. If the data were available and a similar method was applied to the other roads variable one must wonder if we may see a positive effect feed through into GDP given that there are potentially more significant issues with congestion.

Further to this the model developed and tested to account for spatial autocorrelation, and to determine if convergence is occurring between the regions. A summary of the results obtained through this process are shown below:

- "Spatial autocorrelation patterns affect both infrastructure data (although with different values on different infrastructures) as well as GDP growth measures. As a consequence, values of the estimated parameters we previously obtained may be biased. We can correct this bias with the spatial lag model and the spatial error model."
- "Infrastructure growth elasticities change: the effect of direct infrastructure capital change goes from 3% to 7% in the spatial error model, while TLC infrastructure increases in the spatial lag model (7%) and decreases in the spatial error model (4%), compared to the OLS estimate (4%). However, despite differences in magnitude, the effect remains positive and significant for both indicators."

Conclusions drawn from the paper:

- "TLC, direct and indirect types of infrastructure and our main results point in the direction of a significant and positive role of investment in information, overall accessibility, quality and quantity of transport infrastructure on the levels of GDP."

- “The highest rates of return are associated mainly with TLC (internet access for both firms and households and communication networks in general), quality and accessibility of the region’s transportation network (measured by overall accessibility and time to reach the region’s main market), while endowment of traditional road and railway infrastructure has a positive but slightly lower impact.”
- “We also find clear evidence of a convergence process occurring across European regions, and the speed of β-convergence is higher for the NMS [New Member States].”

Public capital and economic growth: a critical survey[25]

The above paper by W. Romp and J. de Haan (2005), provides an overview of both the theoretical and empirical literature that has taken place previously trying to ascertain the link between public investment and economic growth. In doing this they assess both the benefits and weaknesses with the differing models and methods of estimation.

The question is posed as to what we actually want to know and how the link between GDP and infrastructure may look. In evaluating this link we are not only determining the relationship between GDP and infrastructure but also have to ask at what level is infrastructure provided at its optimum and what policies can be used to encourage the most efficient level of growth and investment.

The model selected to model such a relationship will also play a vital role on the inferences for policy.

- "In the exogenous growth model, in which technical progress drives long-run growth, shocks to the infrastructure stock can only have transitory effects. In an endogenous growth model, shocks to infrastructure can raise the steady-state income per capita."

The paper also questions the efficiency of infrastructure spending in context to that of the wider economy. If this investment is funded utilising an increase taxes it may well be the case that not implementing the tax rise would have a greater effect on economic growth than the infrastructure project. In this respect it is important that policy balances the economic benefits and costs of infrastructure not only against similar projects but also on a wider basis.

Market imperfections also increase the complexities of the link between economic growth and infrastructure, increasing the difficulty of defining any specific statistical model.

W. Romp and J. de Haan (2005) explore further issues such as how public capital should be incorporated into production functions. That is to say should public capital be incorporated into the function as an independent element in the

[25] Source: W. Romp and J. de Haan (2005), Public capital and economic growth: a critical survey, vol. 10(1), pp. 40-70.

aggregate function or as a constraint that determines the total factor of productivity of the variables within the function?

Public capital in its self also is unhelpful when trying to model the effects of infrastructure investment on growth given that it may not be provided at market prices and so may not be optimal. Secondly public capital also contains aspects of spending which are outside the remit of what we would consider infrastructure. Often a depreciation rate is also applied to account for the lifespan of infrastructure however at the aggregated level it is difficult to determine exactly what this depreciation rate and period should be given that the lifespan of different infrastructure projects varies significantly.

Some studies try to avoid the above issues by utilising physical measures of infrastructure rather than public spending such as the length of roads and/or railways. Although solving some issues, they do not necessarily link investment expenditure to economic growth and may not always accurately represent the quality and type of infrastructure. For example, the length of a road does not detail the type of geography it passes through which would substantially impact upon costs.

When considering the spillover effects of infrastructure and its implications across national borders it may be the case that the individual national provisions of infrastructure in isolation may be higher than that of the requirement if their efforts were coordinated. This would lead to a sub optimal outcome mitigating any benefits that infrastructure per-say had to offer. The implications from this are that policy within the UK should not only be focused upon the UK in isolation and should account for the integration of the UK infrastructure into that of the EU. This would maximise the benefits of any investment, which would subsequently feed through into economic growth.

Two of the main conclusions that resulted from the study were:

- “Although not all studies find a growth-enhancing effect of public capital, there is more consensus in the recent literature than in the older literature”
- “The effect of public investment differs across countries, regions, and sectors.”

Case studies – measuring the benefits of infrastructure

Due to the difficultly in ascertaining the size of the actual realised benefits of infrastructure investment this report intends to analyse a number of case studies.

It is important to understand how the requirements of project investigations are undertaken and change given carbon and environmental requirements.

In terms of the depth of studies, large infrastructure projects are most likely to be subject to extensive cost benefit analysis. For this reason this report will look in detail at the investigation that took place as part of the Crossrail project.

Given that post project evaluation is not possible on Crossrail, and the inherent difficulty you would face undertaking such a task (causality is hard to establish) considering the large number of people, environmental and economic parameters involved. This report will look to smaller projects as a means of comparing pre and post project evaluations. This should help to assess if the predicted benefits within the project design and conception phase is actually realised once the investment has taken place.

This report recognises there are some limitations in this approach given the relatively small sample of projects that are reviewed and the number of projects where reliable data is available. The correlation of the pre-post project analysis should also not be assumed to be liner given that there may be a bias on some of the smaller projects. The removal of 'bottlenecks' within a system is likely to create greater economic benefits per pound spent than that of a major infrastructure project in the short to medium term.

Large scale projects – Crossrail

As part of the Crossrail project a detailed analysis was undertaken providing an outlook of the potential impact upon the economy, society and its link to economic growth.

Introduction

Crossrail will, as the name suggests, pass directly through London providing a vital expansion of existing capacity between key stations within the City of London. In

addition to this Crossrail will improve commuter services out towards Maidenhead to the west of London, and Shenfield situated out to the east.
Below is a map of the proposed cross rail route, the section in red denotes the parts of the rail service where tunnelling will be required.

Source: Crossrail, http://www.crossrail.co.uk/the-railway/crossrail-wider-economic-benefits

The need for Crossrail

London is continuing to expand with its population set to pass 8 million within the next decade. This poses several challenges for London's existing infrastructure (sewers, roads, rail, and energy) as expansion and modernisation will be required to ensure the city remains internationally competitive.

London poses a challenge given that a significant number of people work within such a small area, overcrowding currently occurring on existing lines and transport hubs within London. For this reason significant investment is required to ensure that future capacity meets consumer demand.

"It is projected that by 2025, over 850,000 people will commute to Greater London every day - an increase of 100,000 people compared with present figures[26]."

Funding

The current funding arrangements for Crossrail utilise both public and private funds via both centralised and localised mechanisms. The funding arrangements are as follows:[27]

- "Government will contribute by means of a grant from the Department for Transport of over £5 billion during Crossrail's construction."

[26] Source: Crossrail, http://www.crossrail.co.uk/the-railway/why-crossrail/need-for-crossrail

[27] Source of funding information: http://www.crossrail.co.uk

- "Crossrail farepayers will contribute towards the debt raised during construction by Transport for London, and Network Rail through projected operating surpluses from the use of Crossrail's services."
- "London businesses will contribute through a variety of mechanisms, including the Supplementary Business Rate."

There are also considerable financial contributions from some key beneficiaries of Crossrail:

- "The City of London Corporation has agreed to make a direct contribution of £200m and in addition will seek contributions from businesses of £150m, and has guaranteed £50m of these contributions."
- "BAA has agreed to a £230 million funding package."
- "Canary Wharf Group has agreed to contribute £150m towards the costs of the new Canary Wharf Crossrail station at Canary Wharf. Canary Wharf Group will also design and build the new station."
- "Berkeley Homes has agreed to construct a station box for a station at Woolwich."

As can be seen from the financial details above, local business and key beneficiaries are to contribute significant sums towards the cost of Crossrail based upon the future benefits the railway will provide. ACE has explored such similar funding mechanisms within its Infrastructure funding paper.

The economic benefits of Crossrail

As part of the appraisal process documentation on the impact of Crossrail on welfare and GDP was produced[28]. The latest economic analysis entitled 'The Economic Benefits of Crossrail[29]' presented the following:

[28] Source: Crossrail, http://www.crossrail.co.uk/the-railway/crossrail-wider-economic-benefits

[29] Source: Crossrail, http://www.crossrail.co.uk/get_asset/5769/0/0/0/0/0/1

Table 6.1: Crossrail Impact on Welfare and GDP Insert Table Title

Benefits	High Scenario		Mid Scenario		Low Scenario	
	Welfare (£m)	GDP (£m)	Welfare (£m)	GDP (£m)	Welfare (£m)	GDP (£m)
Business time savings	4,847	4,847	4,847	4,847	4,847	4,847
Commuting time savings	4,152		4,152		4,152	
Leisure time savings	3,833		3,833		3,833	
Conventional User Benefits	**12,832**	**4,847**	**12,832**	**4,847**	**12,832**	**4,847**
Increase in labour force participation		872		872		872
Move to more productive jobs*		46,165		29,919		19,625
Pure agglomeration*	9,322	14,341	8,204	12,622	6,767	10,410
Imperfect competition	485	485	485	485	485	485
Exchequer consequences of increased GDP	19,218		13,742		9,880	
Additional to conventional appraisal (Wider Economic Benefits)	**29,024**	**61,862**	**22,431**	**43,898**	**17,131**	**31,392**
Total (User and WEBs)	**41,856**	**66,709**	**35,263**	**48,745**	**29,963**	**36,239**

* All entries are 60 years present values discounted to 2002, in 2002 prices

Source: Crossrail

As can be seen from the above the benefits of Crossrail were modelled using three different scenarios. Below are some details regarding the differences within the models:

"The low scenario incorporates only those changes which seem least controversial:"

- "17% International Migration"
- "No cap on output growth; and"
- "Updated Agglomeration Elasticity."

"The mid scenario adds the following changes over and above the Low scenario:"

- "Revised output per employee"
- "Updated employment (2016- 14k, 2026-26k, 2036- 40K)"

"The high scenario then adds the impact of assuming that the number of central London jobs dependent on Crossrail rises to 70,000 by 2026:"

- "Updated employment (2016- 14k, 2026-40k, 2036- 70K)"

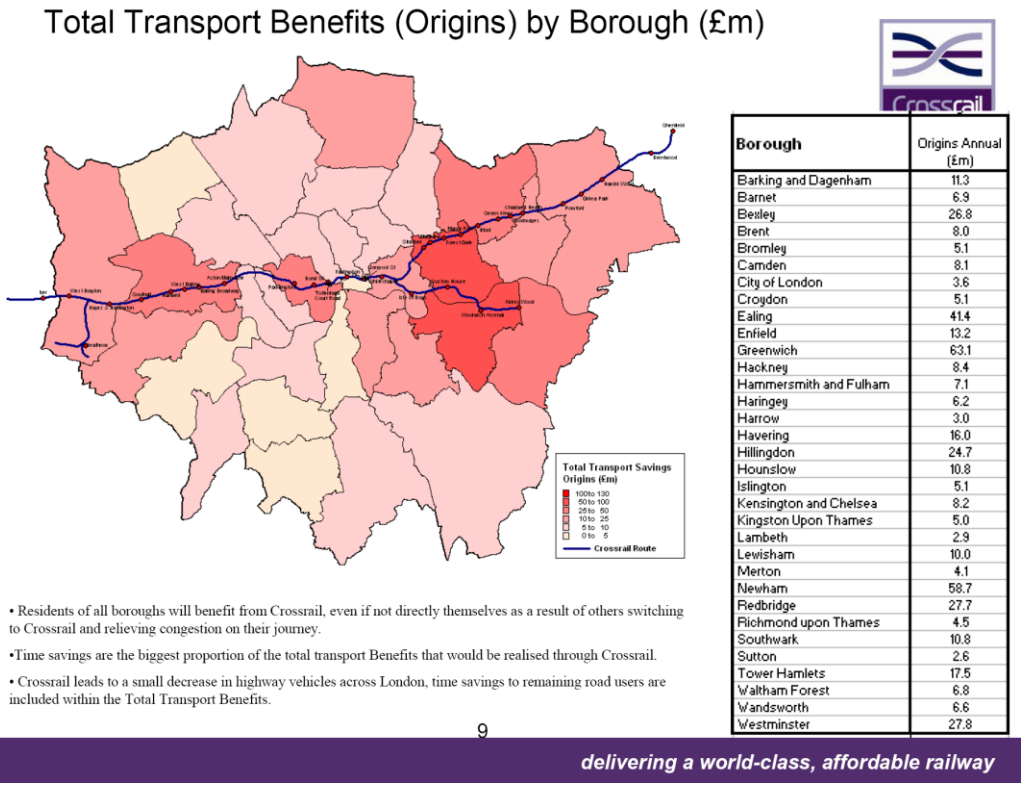
The Impact on welfare and GDP figures reveal:

It is predicted that the total user and welfare benefits from Crossrail will range between £30bn-£42bn, and the economic benefits between £36bn-£67bn.

There are also expected to be significant increases in tax revenues, with government benefiting from between £9bn and £19bn across the various scenarios given the wider economic benefits and the resultant tax revenues. "Even in the low scenario the value of the welfare element of the wider economic benefits is significantly higher than the transport benefits. This is not surprising; Crossrail is addressing a capacity constraint affecting the most productive sector of the UK economy, the benefits from relieving that constraint cannot be measured simply from measuring changes in travel times."

Accompanying this economic analysis was a report documenting the distribution of the economic benefits by region, both within the London boroughs and the South East, entitled 'Distribution of Crossrail Benefits'. A selection of graphics is shown below from the demographic report[30]:

Below are some of the graphical representations included within this report. These detail the transportation benefits, in terms of the origin of passenger, employment and earnings.



Total Transport Benefits (Origins) by Borough (£m)

Crossrail

Borough	Origins Annual (£m)
Barking and Dagenham	11.3
Barnet	6.9
Bexley	26.8
Brent	8.0
Bromley	5.1
Camden	8.1
City of London	3.6
Croydon	5.1
Ealing	41.4
Enfield	13.2
Greenwich	63.1
Hackney	8.4
Hammersmith and Fulham	7.1
Haringey	6.2
Harrow	3.0
Havering	16.0
Hillingdon	24.7
Hounslow	10.8
Islington	5.1
Kensington and Chelsea	8.2
Kingston Upon Thames	5.0
Lambeth	2.9
Lewisham	10.0
Merton	4.1
Newham	58.7
Redbridge	27.7
Richmond upon Thames	4.5
Southwark	10.8
Sutton	2.6
Tower Hamlets	17.5
Waltham Forest	6.8
Wandsworth	6.6
Westminster	27.8

Total Transport Savings Origins (£m)
100to 130
50to 100
25to 50
10to 25
5to 10
0to 5
Crossrail Route

• Residents of all boroughs will benefit from Crossrail, even if not directly themselves as a result of others switching to Crossrail and relieving congestion on their journey.

•Time savings are the biggest proportion of the total transport Benefits that would be realised through Crossrail.

• Crossrail leads to a small decrease in highway vehicles across London, time savings to remaining road users are included within the Total Transport Benefits.

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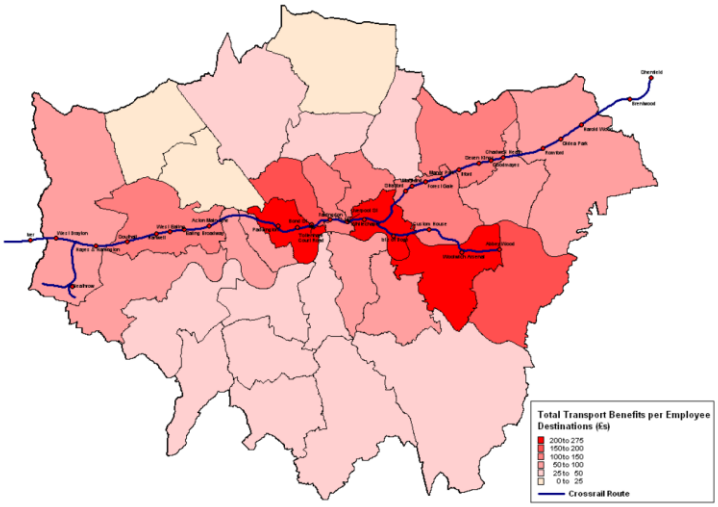
Source: Crossrail

[30] Source: Crossrail, http://www.crossrail.co.uk/get_asset/4996/0/0/0/0/0/1

Transport Benefits per Employee (£s)



Borough	per Employee (£s)
Barking and Dagenham	93.7
Barnet	45.0
Bexley	178.7
Brent	18.9
Bromley	27.6
Camden	158.3
City of London	133.5
Croydon	26.6
Ealing	114.4
Enfield	19.3
Greenwich	235.5
Hackney	110.6
Hammersmith and Fulham	64.3
Haringey	26.4
Harrow	21.3
Havering	85.5
Hillingdon	84.0
Hounslow	52.5
Islington	139.4
Kensington and Chelsea	90.8
Kingston Upon Thames	45.4
Lambeth	47.2
Lewisham	57.9
Merton	34.8
Newham	148.1
Redbridge	123.2
Richmond upon Thames	39.8
Southwark	81.8
Sutton	28.1
Tower Hamlets	240.7
Waltham Forest	31.4
Wandsworth	39.5
Westminster	203.3

• The above map shows the total destination benefits divided by the number of employees in each borough and indicates the extent to which Crossrail will assist employers through faster/easier commutes for their employees.

• The values above are a slight under-estimate as not all employees will use public transport as their means to get to work, so in reality these values per public transport user would be slighter higher.

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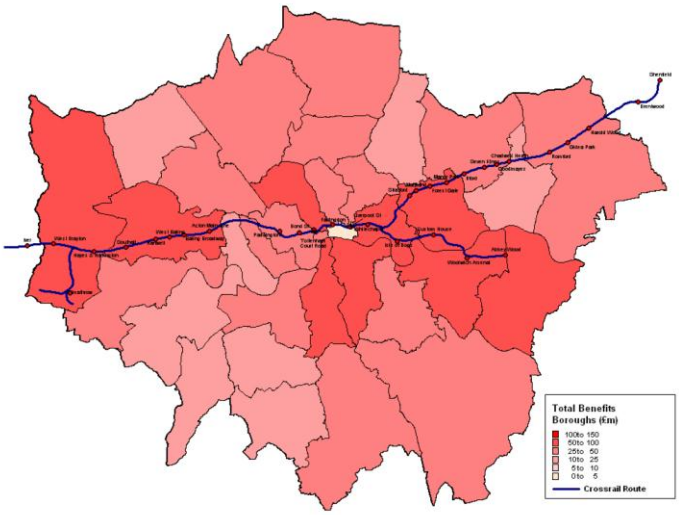
Source: Crossrail

Total Benefits (Transport & Earnings) (£m)



Borough	Total Transport & Earnings (£m)
Barking and Dagenham	16.7
Barnet	30.5
Bexley	58.3
Brent	31.3
Bromley	28.6
Camden	64.0
City of London	4.7
Croydon	29.5
Ealing	56.9
Enfield	27.5
Greenwich	84.5
Hackney	26.1
Hammersmith and Fulham	23.3
Haringey	32.6
Harrow	16.2
Havering	43.3
Hillingdon	58.5
Hounslow	26.6
Islington	40.9
Kensington and Chelsea	35.2
Kingston Upon Thames	18.3
Lambeth	61.0
Lewisham	34.7
Merton	14.3
Newham	99.8
Redbridge	48.9
Richmond upon Thames	21.0
Southwark	58.4
Sutton	13.6
Tower Hamlets	51.8
Waltham Forest	15.4
Wandsworth	25.8
Westminster	47.6

•Total benefits are spread to boroughs not on the Crossrail route and widely to outer London.

• The above maps shows transport benefits and earnings distributed according to where public transport users live, which is why the City receives a low value, due to its small population.

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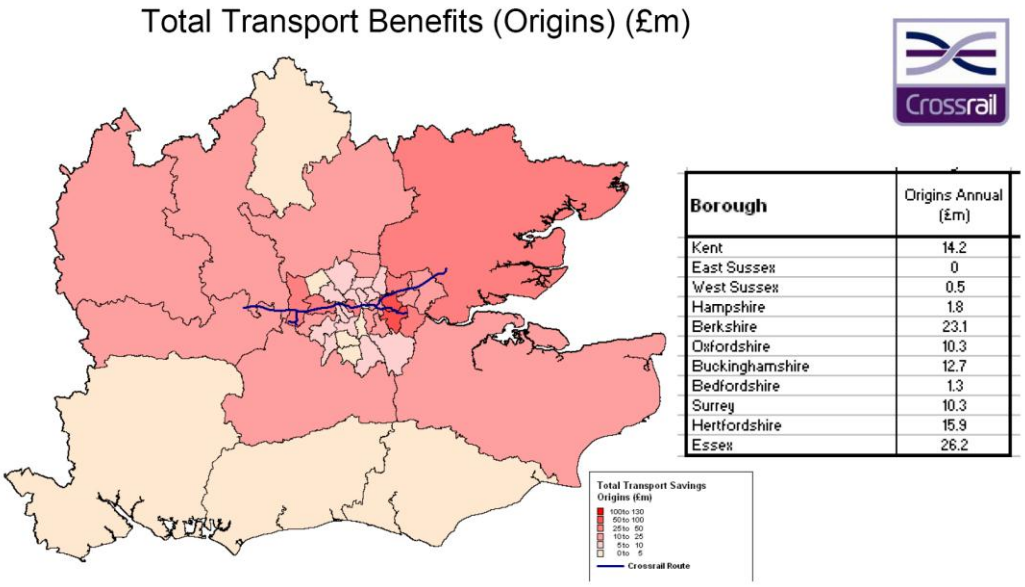
delivering a world-class, affordable railway

Source: Crossrail



Borough	Origins Annual (£m)
Kent	14.2
East Sussex	0
West Sussex	0.5
Hampshire	1.8
Berkshire	23.1
Oxfordshire	10.3
Buckinghamshire	12.7
Bedfordshire	1.3
Surrey	10.3
Hertfordshire	15.9
Essex	26.2

• Crossrail will provide benefits to those using Crossrail for just part of their journey, so the above map shows that those that benefits from Crossrail will be spread far beyond the limits of the railway.

Source: Crossrail

Key figures and trends from the geographical analysis are summarised below:

- All boroughs will benefit from Crossrail, either directly or as a result of other methods of transport intersecting with the project.
- The total benefits to a borough range from £63.1m in Greenwich to £2.9m in Lambeth
- The benefits per employee in terms of their destination of employment range from £240.7 per employee in Tower Hamlets to £18.9 per employee in Brent
- The report notes that: "The values above are a slight under-estimate as not all employees will use public transport as their means to get to work, so in reality these values per public transport user would be slighter higher."
- The analysis of total transport benefits and earnings reveals that the City of London will receive the fewest total benefits (£4.7m), this is because of the relatively low number of residents and population within this area, most activity is generated by commuters.
- Crossrails benefits extend far beyond that of London with Essex benefiting most from the project at an estimated £26.2m a year.

Further analysis can be found in original document, but the above demonstrates how widely the effects of Crossrail will be distributed, contributing to improved transport capacity, utilisation, employment, productivity and growth potential.

Unfortunately at this point in time we are unable to assess if the 'predicted' benefits of Crossrail will come to fruition but given the investigations that have taken place current indications are that there will be a positive effect on economic growth within London and the South East.

Smaller scale case study projects – Highways Agency

Smaller projects can result in significant benefits by removing bottlenecks and constraints within the current infrastructure systems, improving economic, social and environmental conditions locally.

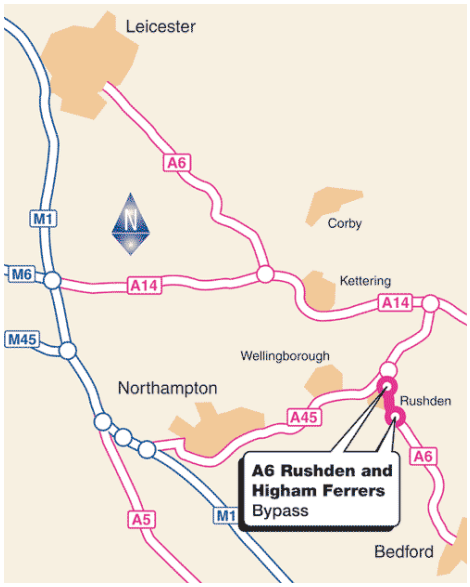
The following examples are from the highways agency, these have been selected for the following reasons:

- The projects have a direct influence upon the local community, economy and environment but do also have wider economic implications.
- The cost benefit studies have been conducted not only prior to but also following projects, providing an accurate picture of the potential vs realised benefits and costs of the investments.

Example Project 1 - A6 Rushden and Higham Ferrers Bypass[31]

Background

The A6 Rushden - Higham Ferrers Bypass, was the subject of two public enquires and eventually was included in the Targeted Programme of Improvements in 1998. The work was performed under a 'design and build contract', during the project the winning contractor unfortunately entered administration and so another contractor had to be found.



Source: Highways Agency

The bypass is 5.5km (3.4 miles) long, consisting of 2.3km of dual carriageway, and 3.2 km of single carriageway. It finally opened on the 14 August 2003.

On the next page is a copy of the Appraisal Summary Table (AST) for the A6 Rushden and Higham Ferrers Bypass. These are used by the Highways agency to ascertain the following:

[31] Source: Highways Agency, http://www.highways.gov.uk/roads/projects/4490.aspx

- "An Appraisal Summary Table is a summary of key consequences relating to the environmental, economic and social impacts of a trunk road scheme. They are used to help determine which trunk road schemes should proceed and, if they do, to decide which options to choose."

Appraisal Summary Table

Table 5.1 – Appraisal Summary Table

A6 Rushden & Higham Ferrers (GO-EM)	Option: 1996 scheme – 5.5km part D/2 part S/C carriageway	COST: £9.4m

PROBLEMS	Severe safety, journey time reliability and environmental problems through the towns of Rushden (pop: 24,000) and Higham Ferrers (pop: 5,400) Northants, due to tortuous alignment of A6 and high volumes of traffic (19,700 vpd, 6%HGV).
OTHER OPTIONS	Alternative bypass routes were rejected. Rail improvements unlikely to remove sufficient traffic to solve problem.

CRITERIA	SUB-CRITERIA	QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
ENVIRONMENTAL IMPACT	**Noise**	Removal of traffic to new route benefits properties in existing road but has adverse effects on others (about 700 properties experience smaller increases or decreases in noise level).	No. properties experiencing: -Increase in noise 150 -Decrease in noise 70	Net 80 properties lose with scheme
CO2 tonnes added 0 - 2000	**Local air quality**	Considerable improvement due to traffic being removed from centre of towns.	No. properties experiencing: -Improved air quality 520 -Worse air quality 25	-239 PM_{10} -1471 NO_2
	Landscape	No significant impact	-	Neutral
	Biodiversity	No significant direct impact	-	Neutral
	Heritage	Substantial benefits for integrity and context of two towns' Conservation areas, including numerous listed buildings	-	Large +ve
	Water	Even with mitigation, there may still be a significant risk of polluting very sensitive groundwater during both construction and operation; and an impact on local drainage	-	Moderate -ve
SAFETY	-	Safety benefits due to separation of through traffic from pedestrians and local traffic and improved standard of new road.	Accidents Deaths Serious Slight 426 4 93 386	PVB £3.9m 72% of PVC
ECONOMY	**Journey times & VOCs**	High journey time improvements due to removal of traffic from one-way system in Rushden	peak inter-peak 7.9 mins 8.0 mins	PVB £47.7m 878% of PVC
	Cost	-	-	PVC £5.4m
	Reliability		Route Stress Before 85% After 23%	+ve
	Regeneration		Serves regeneration area?	No
ACCESSIBILITY	**Public Transport**	No significant impact	-	Neutral
	Severance	Removal of through traffic in Higham Ferrers (78%) and Rushden (20%) will greatly reduce severance.	-	Large +ve
	Pedestrians and others	Reduction in traffic will increase accessibility for pedestrians and cyclists in the town.	-	Large +ve
INTEGRATION	-	Scheme identified in Transport Policy in Approved Northants Structure Plan and in new Draft. Development of 1780 homes and 59ha employment land dependent on new bypass being provided. Northants CC structure Plan identifies East of Wellingborough Development Area which would be facilitated by scheme.		+ve

COBA		PVB £51.6m PVC £5.4m NPV £46.2m BCR 9.49

Source: Highways Agency

From the above the initial assessment of the investment it was concluded:

- The problems were severe safety concerns, journey reliability, and environmental problems through town.
- Only 80 properties would lose out regarding increased noise levels.
- Overall air quality would be improved considerably by moving the road away from the town.
- The heritage of the two towns would be improved by not having a busy road running through their centres.
- Water pollution would suffer a moderate negative impact
- Safety would improve by 72% of the Present Value of Cost (PVC) or £3.9m
- The economic effect of the project were rated as follows, with a Present Value of Benefit (PVB) of £47.7m in terms of journey times and the PVC would equal £5.4m
- There would be large positive effect in terms of severance within the towns and an increased level of accessibility for pedestrians and cyclists
- Overall project Benefit Cost Ratio (BCR) 9.49

From the above it was concluded that the project was worth undertaking and given the combination of positive effects and the overall BCR, this project should produce significant economic benefits in relation to the construction cost.

Post Opening Project Evaluation (POPE)

As mentioned previously part of the reason for selecting these projects for analysis is the ability to asses the impact of the project following their completion. The post opening project evaluation (POPE) for the A6 Rushden - Higham Ferrers Bypass can be found here:

http://www.highways.gov.uk/roads/projects/4490.aspx

Within the POPE the following findings were reported one year after opening[32]:

- "The A6 bypass immediately after opening carried on average 9,270 vehicles per day (vpd). In the one year after opening period this traffic figure has now increased to 11,700 vpd, a 26% increase."
- "The 'old' A6 between Rushden and Higham Ferrers, for the period immediately before opening, carried 21,700 vpd. This reduced to 15,900 immediately after opening and now, one year after opening is carrying on average 18,100 vpd. This represents an overall reduction of 16.5%."
- "The ratio of daily traffic to road capacity, known as route stress, on the 'old' A6 through Rushden and Higham Ferrers has decreased from 85% to 63%. This reduction in route stress helps to explain an overall improvement in route journey times."
- "Based on a single year's accident data, the opening of the bypass has had little impact on the overall accident rate along the route. The new road does, however, have a good accident rate, below the national average."
- "The impact of the A6 bypass on the environment has not yet been fully analysed. However, both the noise and air-quality 'sub-criteria' assessments contained in the scheme AST will have been partially achieved through the reduction in through traffic observed in the towns of Rushden and Higham Ferrers."

The above shows that, after opening road usage and traffic flow has increased, this equates to a better experience for consumers and time savings which will equate to improved productivity. However, it is noted that the environmetal impacts of such increases in traffic are currently too early to asses and so may in time reduce the overall economic benefit of such a project.

"In order to assess the actual or outturn effects of the improvement scheme, an Evaluation Summary Table (EST) has been completed, in the same format of the AST, and includes details of the actual sub-objectives that have been evaluated[33]."

[32] Source: Highways Agency, http://www.highways.gov.uk/roads/documents/A6_Rushden_and_Higham__Ferrers_Bypass_One_Year_After_Study.pdf

Evaluation Summary Table

Table 5.2 – Evaluation Summary Table

A6 Rushden & Higham Ferrers (GO-EM)	Option: 1996 scheme – 5.5km part D/2 part S/C carriageway	COST:

PROBLEMS	

OTHER OPTIONS	Not evaluated at this stage.

CRITERIA	SUB-CRITERIA	QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
ENVIRONMENTAL IMPACT	Noise	Benefit from the removal of through traffic from the towns. Properties at the eastern edges of both towns may experience a small negative impact. Closed board fencing softens impact.	Not measured at this stage	Expected small negative benefit
CO2 tonnes added 0 - 2000	Local air quality	A small benefit from the removal of through traffic from the towns.	Not measured at this stage	Expected small positive benefit
	Landscape	Tree and shrub planting softens impact of bypass.	-	Slight -ve
	Biodiversity	No impact expected.	-	Neutral
	Heritage	AST prediction expected to be true	-	Large +ve
	Water	Not known at present	-	-
SAFETY	-	Less traffic in towns expected to have a positive impact on traffic and pedestrian accidents.	Accidents Deaths Serious Slight 293 -1 13 281	PVB £16.8m 131% of PVC
ECONOMY	Journey times & VOCs	-	peak inter-peak 4.3 mins 4.0 mins	PVB £13.1m 102% of PVC
	Cost	-	-	PVC £12.8m
	Reliability		Route Stress Before 85% After 63%	
	Regeneration		Serves regeneration area?	No
ACCESSIBILITY	Public Transport	No benefits expected	-	Neutral
	Severance	Reduces severance by removal of through traffic (16% in Rushden, 46% in Higham Ferrers)	-	Moderate +ve
	Pedestrians and others	Removal of through traffic improves environment for pedestrians and others. Footbridges on bypass also have a positive impact.	-	Moderate +ve
INTEGRATION	-	The provision of the bypass is in line with Approved Northants Structure Plan and will allow both residential and employment development.		

COBA		PVB £29.8m PVC £12.8m NPV £17.0m BCR 2.3

Source: Highways Agency

[33] Source: Highways Agency, http://www.highways.gov.uk/roads/documents/A6_Rushden_and_Higham__Ferrers_Bypass_One_Year_After_Study.pdf

As can be seen from the above the BCR is not as high as anticipated in the appraisal stage of the project, with post evaluation revealing a ratio of 2.3 compared to the initial 9.49. However, it most be noted that this is the lower estimate of the two models used when inputting the data following a year's operation (as can be seen in the table below).

Table 4.8 – Benefit Cost Ratio

(All prices in 1998 costs and values)	Predicted	Outturn	
		POPE method	COBA method
Present Value Benefit (PVB) Forecast over 30 years	£36.2m	£29.8m	£48.9m
Present Value Cost (PVC)	£10.5m	£12.8m	
Benefit Cost Ratio (BCR)	3.5	2.3	3.8

Source: Highways Agency

Although this is a significant downward revision the economic benefit from the project still equates to 2.3 times the cost of the project.

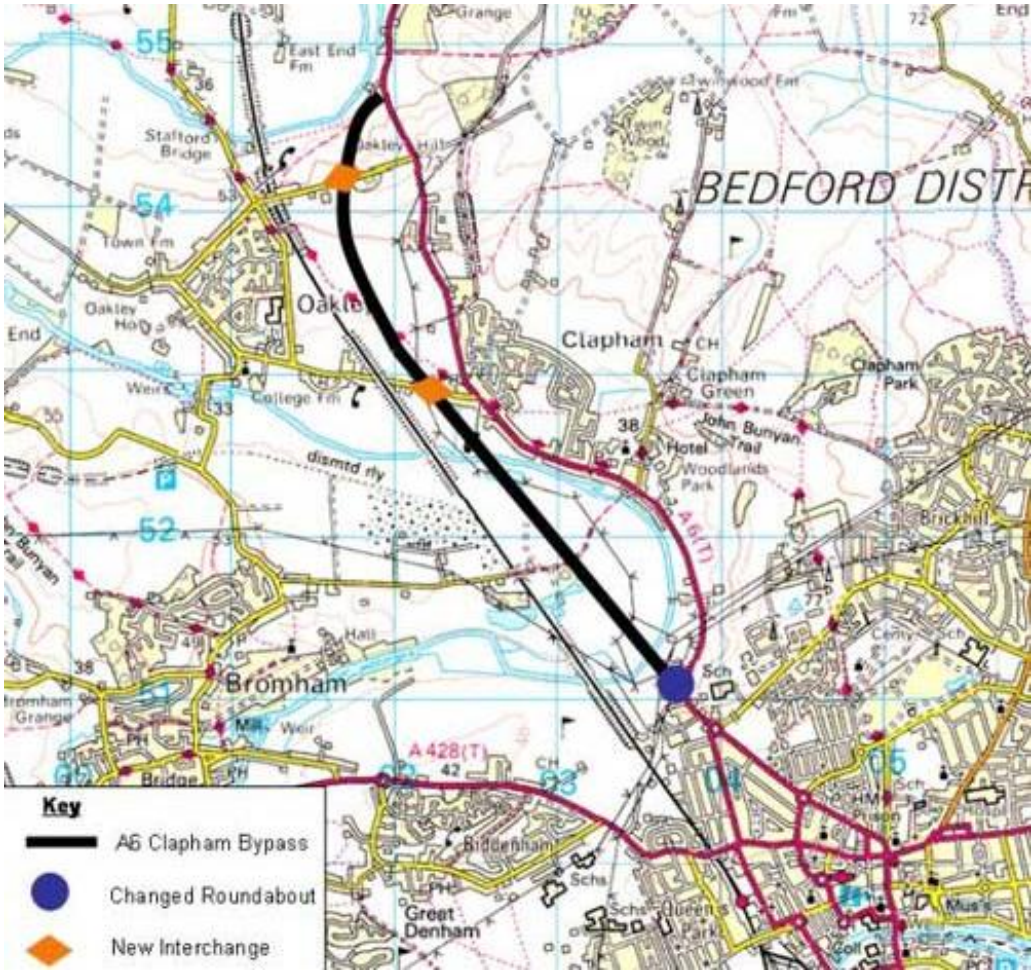
As can be seen from the above AST and EST statements the majority of the revision was attributable to the PVB of journey times (which was lower than anticipated) and safety (which was higher than anticipated).

It is important to remember that whilst the environmental effects have not yet been taken into account within this project evaluation (which may reduce the overall level of the benefits) there is also the possibility that the economic benefits may in the future equate to be larger than those reported above. For example, this would occur if usage continued to increase, increasing demand for the road until the point of optimum capacity (It is important that the level of usage does not surpass this point, at which point the road becomes congested and economically inefficient).

Example Project 2 – A6 Clapham Bypass[34]

Background

The A6 Clapham Bypass opened on 12th December 2002, the scheme required the construction of a 5 km long new section of dual carriageway. A map of the rout is shown below.



Source: Highways Agency

As with the previous project an appraisal assessment was undertaken before the project took place and we will compare this to the actual results of the infrastructure investment realised results a year later.

[34] Source: Highways Agency, http://www.highways.gov.uk/roads/projects/6006.aspx

A6 Clapham, Bedford (GOER)	1996 scheme - 5km D2 bypass	Cost £30.9m

PROBLEMS	Poor safety and environment within Clapham (pop 3,200) where A6 carries up to 21,000 vpd (7% HGV). 300 residential properties + 2 schools front on to the road. Peak hour queuing occurs on length between village and northern outskirts of Bedford.
OTHER OPTIONS	2 Pelican crossings already provided in village. Large scale traffic calming scheme would have unacceptable noise, air pollution and severance effects. Other options considered include reduced standard single carriageway bypass on proposed line; an eastern bypass and improved rail services to new Bedford North station with park and ride. All have inferior benefits.

CRITERIA	SUB-CRITERIA	QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
ENVIRONMENTAL IMPACT CO2 tonnes added 0 - 2000	**Noise**	Properties within Clapham benefit from removal of traffic	No. properties experiencing: - Increase In Noise 15 - Decrease in noise 316	301 properties experience net decrease in noise
	Local air quality	Removal of through taffic by bypass will improve air quality within Clapham	No. properties experiencing: - improved air quality 400 - worse air quality 0	-409 PM10 -2549 NO2
	Landscape	Bypass partially within local areas of Great Landscape Value and would result in loss of pasture land	-	Slight -ve
	Biodiversity	County Wildlife Site affected	-	Slight –ve
	Heritage	No significant impacts.	-	Neutral
	Water	Even with mitigation, there may still be a significant risk of polluting a sensitive watercourse and an aquifier used for public water supply during both construction and operation; and an impact on flood risk as the scheme is within a floodplain and bridges a river.	-	Moderate –ve
SAFETY	-	Bypass reduces pedestrian/vehicle conflict in village and replaces a section of poor standard single carriageway.	Accidents Deaths Serious Slight 311 9 94 359	PVB £10.5m 54% of PVC
ECONOMY	**Journey times & VOCs**	Faster journey times on new bypass	Peak Interpeak 4.6 mins 3.5 mins	PVB £27.6m
	Cost			PVC £19.6m
	Reliability		Route Stress Before 104% After 38%	Slight Low rel to PVC
	Regeneration		Serves regeneration priority area?	No
ACCESSIBILITY	**Public Transport**	Will help to reduce peak journey times of existing local bus services	-	Slight +ve
	Severance	Removes 80% of traffic from village	-	Moderate +ve
	Pedestrian/other	Will improve accessibility for residents to local services		Moderate +ve
INTEGRATION	-	Complements Bedford/Kempston package proposals and facilitates proposed Bedford North rail station with park and ride. Assists proposed local residential and commercial developments	-	Positive

COBA		
		PVB £38.2m PVC £19.6m NPV £18.5m BCR 1.95

Source: Highways Agency

The initial assessment of the investment concluded:

- 301 properties would experience a net decrease in noise
- 400 properties would experience improved air quality
- Slightly negative impacts on the landscape, biodiversity and a moderate negative impact on water quality
- Safety would benefit to the value of £10.5m, which equates to 54% of the PVC
- Journey times would provided a PVB of £27.6m
- The cost of the scheme would be approximately £19.6m
- There were also slight to moderate improvements predicted for severance, public transport and pedestrian accessibility
- The overall BCR equals 1.95

Once again following the project a Post Opening Project Evaluation (POPE) was carried out and as part of the outcomes a revised Evaluation Summary Table (EST).

A6 Clapham, Bedford (GOER)	2002 scheme - 5km D2 bypass	Cost £26.7m
PROBLEMS SOLVED	Indication of reduction in traffic flows on the A6 through Clapham from between 15,000 - 23,000 vehicles per day to 2,000 – 8,.500 vpd. Proportion of HGV's using A6 through Clapham reduced from 8% to 2%.	
OTHER OPTIONS	Not assessed	

CRITERIA	SUB-CRITERIA	QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
ENVIRONMENTAL IMPACT	Noise	No assessment specifically made – but AST conclusions are likely to be valid as traffic volumes have been significantly reduced in village	-	Large +ve
	Local air quality	No assessment specifically made – but AST conclusions are likely to be valid as traffic volumes have been significantly reduced in village		Large +ve
	Landscape	Not assessed		-
	Biodiversity	Not assessed		-
	Heritage	No assessment specifically made – unlikely to be significant impacts.	-	-
	Water	Not assessed	-	-
SAFETY	-	Bypass reduces pedestrian/vehicle conflict in village and replaces a section of poor standard single carriageway.	Accidents Saved 220	PVB £9.9m
ECONOMY	Journey times & VOCs	Faster journey times on new bypass	Peak 5 mins Interpeak 4.5 mins	PVB £31.3m
	Cost			PVC £18.4m
	Reliability		Route Stress Before 79% After 28%	Slight Low rel to PVC
	Regeneration	Not assessed	-	-
ACCESSIBILITY	Public Transport	Not assessed	-	-
	Severance	60-75% of traffic has been removed from the village, thus greatly reducing the severance.	-	Moderate +ve
	Pedestrian/other	60-75% of traffic has been removed from the village, thus greatly improved the environment for pedestrians and others.		Moderate +ve
INTEGRATION	-			

COBA					
		PVB £41.3m	PVC £18.4m	NPV £22.9m	BCR 2.24

Source: Highways Agency

Below are some of the key points from the One Year Evaluation of the A6 Clapham Bypass TPI Scheme[35];

- "75% of traffic has been removed from the bypassed section of old A6 in Clapham suggesting that the schemes have been successful in removing through traffic from the village;"
- "The OPR AST predicted a total benefit of £38.2m comprising of £27.6m journey time and VOC savings with £10.5m of accident savings in 1994 prices discounted to 1994. The POPE methodology produced total benefits of £41.3m comprising of £31.3m journey time savings and £9.9m of accident savings in 1994 prices discounted to 1994."
- "Journey time information suggests that time savings of between 2 to 3 minutes are being forecast for journeys along the 5km length of the bypass compared to the corresponding route along the A6 through Clapham. "
- "The completion of the A6 has led to a reassignment of traffic onto the road and new trips, and the benefits from these trips have not been incorporated as the POPE methodology."
- "The predicted scheme costs for the A6 Clapham bypass were estimated to be £30.9m in 1994 prices. This outturn costs were £27.7m in 1994 prices although this could increase as there are still Land Compensation Act claims outstanding."
- "The A6 Clapham Bypass has led to a reduction in the number of accidents in the corridor, where up to 7 personal injury accidents have been saved in the first year after opening."

As can be seen from the above this scheme has proven to be very successful and unlike the previous project also has a BCR higher than that originally anticipated (2.24) in the initial study (1.95).

This project shows a far greater level of accuracy within the pre and post project evaluation providing a greater level of certainty with respect of the economic outcomes. If project evaluations could consistently deliver (within a reasonable degree of certainty) the benefits of such projects the confidence and availability of

[35] Source: Highways Agency, http://www.highways.gov.uk/roads/documents/one_year_report.pdf

funds from the private sector would be likely to increase given that the risks are transparent and so can be mitigated against.

Example Project 3 - A30 Merrymeet Junction[36]

So far the previous two projects have looked at the economic, social and environmental studies that have taken place as part of building a bypass. However, not all road projects will be of this type and, so for this third and final example from the Highways Agency, we look at the improvement of the A30 Merrymeet Junction.

Background

"The scheme was the improvement of the junction between the A30 trunk road, a dual carriageway in Devon between Exeter and Okehampton, the A382 single carriageway and a minor road. It consisted of the following measures:[37]"

- "Removal of the at-grade four arm Merrymeet roundabout;"
- "Construction of a new bridge over the A30 and associated merge and diverge lanes providing full junction movements; and"
- "Environmental mitigation measures."

Appraisal Summary Table

The above project being newer than the previous two has a wider remit in the initial study as to the impacts of the project. The AST study found that:

- There would be no significant changes in the levels of air quality, noise and townscape as a result of the project.
- There would be a neutral effect on the landscape, water, physical fitness, journey ambience, reliability severance, access to transport ad other government policies.
- The effect on CO_2 emissions of the scheme were found to be slightly adverse, with an increase on the do nothing scenario levels for both 2006 and 2021.
- The economic benefits are now presented as ranges providing which would effectively represent 'confidence bands' within an estimation model.
  - Consumer Users PVB £10.6m-£12.7m
  - Business Users PVB £8.2m-£9.9m

[36] Source: Highways Agency, http://www.highways.gov.uk/roads/projects/3504.aspx

[37] Source: Highways Agency, http://www.highways.gov.uk/roads/documents/POPE___A30_Merrymeet_OYA_summary___final.pdf

  - Public Accounts PVC £7.9m-£7.5m
- The safety benefits would equate to the following:
  - PVB £21.1m Low Growth
  - PVB £24.7m High Growth
- This results in:
  - NPV £32.0m - £39.7m
  - BCR 5.1-6.3

A full copy of the Appraisal Summary Table can be seen on the following page.

Option – Grade Separated Junction	Description – Existing junction on A30 at Merrymeet grade separated by removing the roundabout and providing a free flowing A30 with associated merge and diverge lanes and a connecting bridge.	Problems – This is the only roundabout along the A30 Dual Carriageway between Exeter and Okehampton, requiring drivers to slow down and Give Way. The roundabout has an accident problem and suffers frequent delays, particularly during times of peak holiday traffic.	Present Value Cost to Government £6.5m

OBJECTIVE	SUB-OBJECTIVE	QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
ENVIRONMENT	Noise	Noise levels not assessed as change in traffic levels < 25%	Not assessed	Not significant
	Local Air Quality	No changes in traffic flows of 10% or more are expected as a result of the Published Scheme. Local Air Quality has therefore been scoped out from the appraisal as per guidance in TAG Unit 3.3.1	Not assessed	Not significant
	Greenhouse Gases	For both 2006 and 2021 scenarios, the total CO_2 emissions predicted with the Scheme in operation (Do-Scheme) are slightly higher than those predicted for the Do-Minimum scenario. The effect of Scheme is therefore considered to be slightly adverse.	CO_2 – tonnes per year DO MINIMUM Present (2003) = 3,543 Do-Minimum 2006 = 3,860 Do-Minimum 2021 = 4,366 DO SOMETHING Do Something 2006 = 4,276 Do Something 2021 = 4,760	CO_2 – tonnes per year (Change) 2006 (DM - DS) = + 416.01 2021 (DM - DS) = + 394.82
	Landscape	Some loss of established highway planting but some attenuation of notch effect of A30 seen from NW. New planting, reduced lighting and new bridge would redress the balance.		Neutral
	Townscape	Not Applicable		Not significant
	Heritage of Historic Resources	No nationally important archaeological sites or buildings will be affected by the proposals. There would be a loss of potential archaeological deposits identified by geophysical survey and approximately 170m of historically 'important' hedgerows also would be removed.		Slight adverse
	Biodiversity	Some species rich Devon hedgebanks would be partially lost, together with some areas of species rich grassland, although both would be largely mitigated by new planting. Some minor impact is likely on habitats for reptiles, badgers, dormice and breeding birds, although these are largely mitigated within the scheme design.		Slight Adverse
	Water	Environment Surface water drainage from new carriageway areas to utilise existing surface water drainage system and additional paved area mitigated by additional attenuation/interception.		Neutral
	Physical Fitness	No change in number of trips by pedestrians or cyclists		Neutral
	Journey Ambience	No change to Traveller Care Indicators, views would be largely unchanged. Stress would remain as Low with the scheme in place.		Neutral
SAFETY	Accidents	Total Accident Impact identified at this stage.	Decrease 243 PIA (60yr Low Growth) Decrease 287 PIA (60yr High Growth)	PVB £21.1m Low Growth PVB £24.7m High Growth
	Security	Reduced congestion, large reduction in traffic slowing down		Neutral
ECONOMY	Transport Economic Efficiency	Reduced congestion and improved journey times as a result of new layout.	NPV £32.0m - £39.7m BCR 5.1-6.3	Consumer Users PVB £10.6m-£12.7m Business Users PVB £8.2m-£9.9m Public Accounts PVC £7.9m-£7.5m
	Reliability	Scheme causes slight improvements in journey times through junction.	Driver Stress – Do Min 28%. Do Something 28%	Neutral
	Wider Economic Impacts	Not designated Regeneration Area - However does serve Devon and Cornwall	Regeneration Area Development depends on scheme	No
ACCESSIBILITY	Option values	Not applicable for road schemes		N/A
	Severance	No direct severance effects		Neutral
	Access to the Transport System	No provision for the increase of routes or frequency of public transport.		Neutral
INTEGRATION	Transport Interchange	None	N/A	N/A
	Land-Use Policy	Facilitation of national, regional and local transport and economic policies outweighs hindrance of regional and local polices on protection of agricultural land, landscape and cultural heritage		Beneficial
	Other Government Policies	Complies with relevant Government policies.		Neutral

Source: Highways Agency

Once completed the subsequent POPE summary report found that the following had been achieved:

Objectives	Objective Achieved?
Improve safety by removing problems particularly associated with A30 traffic stopping at the roundabout, including a high rate of fatalities;	Too soon to judge
Reduce congestion occurring at the roundabout at peak times, and during the holiday period;	Yes
Reduce journey times for A30 through traffic;	Yes
Retain full turning movements at the junction;	Yes
Avoid environmental impact on Dartmoor National Park which lies on the highway boundary; and	Yes
Reduce environmental effects as far as practicable	Partially but too soon to judge all

Source: Highways Agency

Main Impacts

Environment	– Impacts largely as predicted – Lighting reported to be an improvement – Too soon to evaluate new landscape planting and replacement habitats
Safety	– Too soon to determine statistical significance of minor reduction in accidents at the junction and slight increase over wider area – No fatal or serious accidents at junction since 1999
Economy	– A30 through traffic benefits from removal of roundabout – Above forecast traffic levels means than journey time benefits are above forecast
Accessibility	– Benefits a small number of non motorised users and buses
Integration	– Consistent with planning policies for South West Assembly, Devon County Council and Dartmoor National Park.

Source: Highways Agency

Economic Summary

	Forecast [2]	Actual [2]
60 year Benefits [1]	£47.3m	£39.3m
Capital Cost of scheme	£7.4m	£8.9m
Benefit Cost Ratio	6.3	4.3

1. Benefits based on forecast savings in accident reduction and improved journey times.
2. All prices in 2002 prices, discounted to 2002 at 3.5%.

Source: Highways Agency

This scheme was successful, reducing congestion, improving journey times and to a lesser extend mitigating the environmental impact of the junction. Although over estimated the final BCR was reported as being 4.3. This compares to the initial range of 5.1 (low growth) to 6.3 (high growth).

Inferences from Highways Agency projects

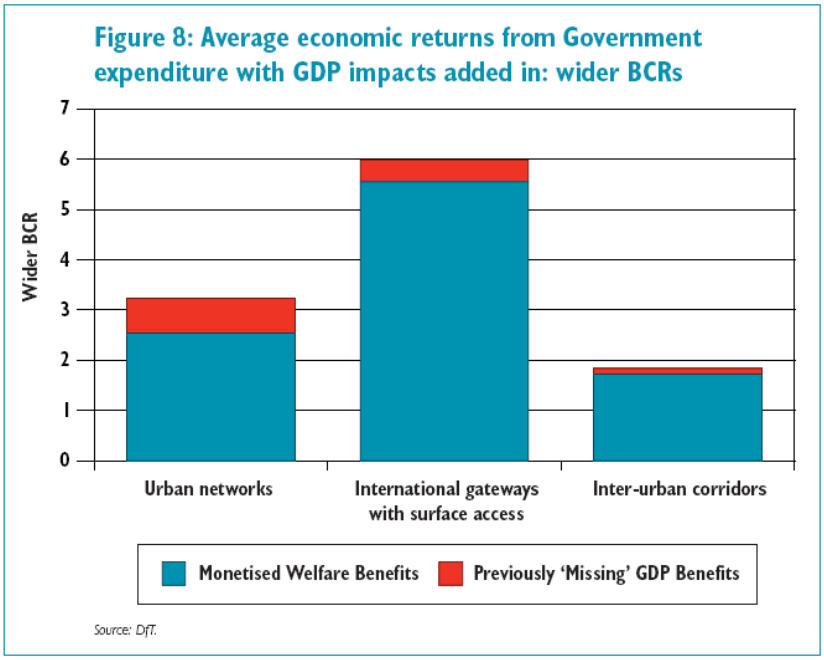
- The case studies we have used demonstrate that good value for money can be derived from investment on roads with investment resulting in an 'economic benefit' of approximately 2 times or greater.
- The AST and EST documents show that the highways agency, designers and contractors are aware of the government's commitment to reduce the environmental impact of projects.
- The UK's policies to ensure that safety on roads remains a priority with low fatalities and serious injuries, this is contributing positively to the economic benefits of projects, although it should be noted that in some cases this may actually increase the initial cost of projects above and beyond any benefits received and so may in effect lower their BCR.
- Two of the projects show that the pre-project evaluations have been reasonably accurate at determining the actual cost and benefits measured post project completion. However, the first project demonstrated the need to continually improve these models to provide an accurate representation of the direct, social and wider benefits of projects in an effort to provide transparency and confidence amongst contractors, consumers, communities and investors
- The projects demonstrate that although the UK will no doubt benefit from national projects, such as Crossrail and high speed rail, that smaller targeted projects continue to hold a lot of economic potential. For this reason it is important that government policy is wide ranging. A situation whereby government policy adopts a 'tunnel vision' policy approach (focusing upon only the large iconic projects) would potentially be detrimental to economic growth. It is important to remember that the existing infrastructure forms an integral part of UK transportation, transmission, etc. If these connections are allowed to degrade, apart from the direct implications to economic growth, these poorer connections will ultimately negate the benefits of any new infrastructure as the economic benefits are not transmitted as effectively to different parts of the economy.

Department for Transport – The Eddington Transport Study

The economic returns and wider economic benefits of transport infrastructure

The information below has been taken from the summary report of The Eddington Transport Study (December 2006)[38] and demonstrates the economic benefit attainable through investment in transportation infrastructure.

The study takes the conventional BCR and attempts to calculate a more complete Value for money (VfM BCR). This ratio attempts to build in the missing GDP impacts and environmental valuations, and account for further microeconomic variables to paint a more complete picture of the true effects of transportation investment.



Source of chart: DFT, The Eddington Transport Study

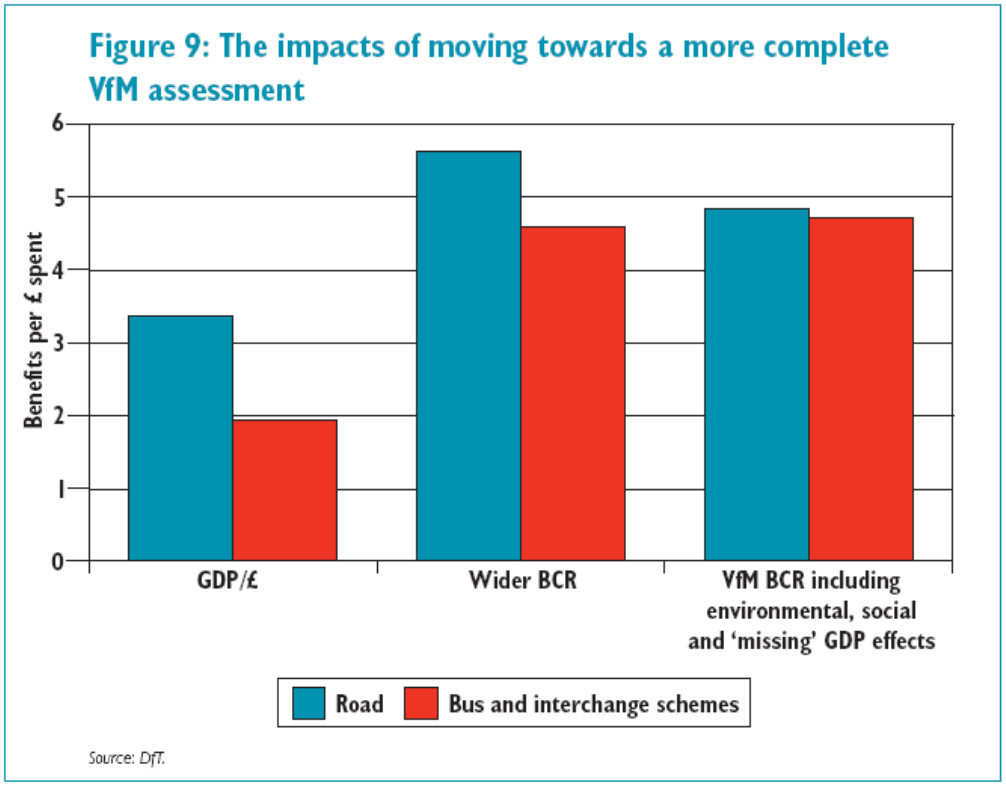
The potential returns from transportation investment, are in line with those previously discussed in this report. However, the segmentation of the differing

[38] Source: DFT, The Eddington Transport Study (December 2006) http://www.dft.gov.uk/adobepdf/187604/206711/executivesummary.pdf

circumstances under which transport infrastructure operates does provide some valuable insight into the types of projects which provide the 'best' economic return.

- "surface access schemes to international gateways provide an average return of £6 per £1 of government expenditure."
- "urban areas show an average return of over £3 per £1 of government expenditure."
- "Inter-urban routes show an average return of just under £2 per £1 of expenditure, though this rises to just under £5 once some very large and expensive rail infrastructure options are removed from the average."

As we discuss later in this paper the majority of travel in the UK still occurs via road and so investment in this resource is key. The Highways Agency case studies have demonstrated that actual economic returns of between 2.2 to 4.3 have been achieved in the past. The Eddington Transport Study attempts to factor in wider economic benefits, social and environmental aspects.



Source of chart: DFT, The Eddington Transport Study

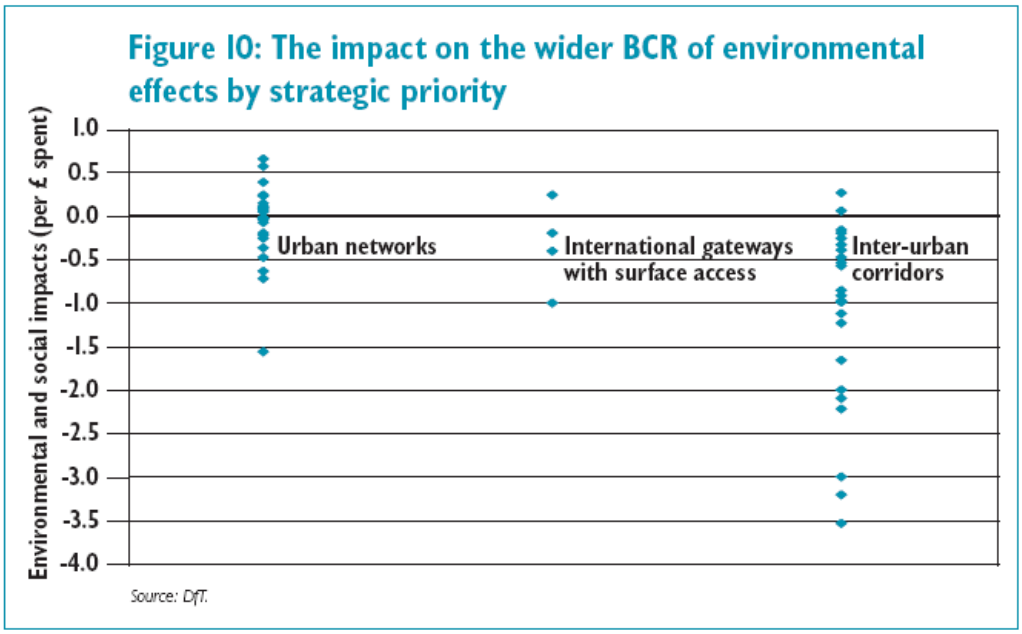
Given the above the report concluded that:

- "The wider BCR estimates show that the narrow GDP measure misses a very substantial proportion of the benefits provided by these projects, particularly on public transport schemes"
- "Adding in environmental and social impacts to look at the fullest measure of welfare (the VfM assessment), knocks around one point off the average for road schemes"

This reinforces the view that positive social effects and economic growth are transmitted to the wider economy through investment in infrastructure such as roads and bus and interchange schemes.

The wider economic benefits are not necessarily the same for any given project and are quite sensitive to location, and so to explore their effect in more detail the Transport Study plots the variance of their effect upon the current benefit cost ratio.

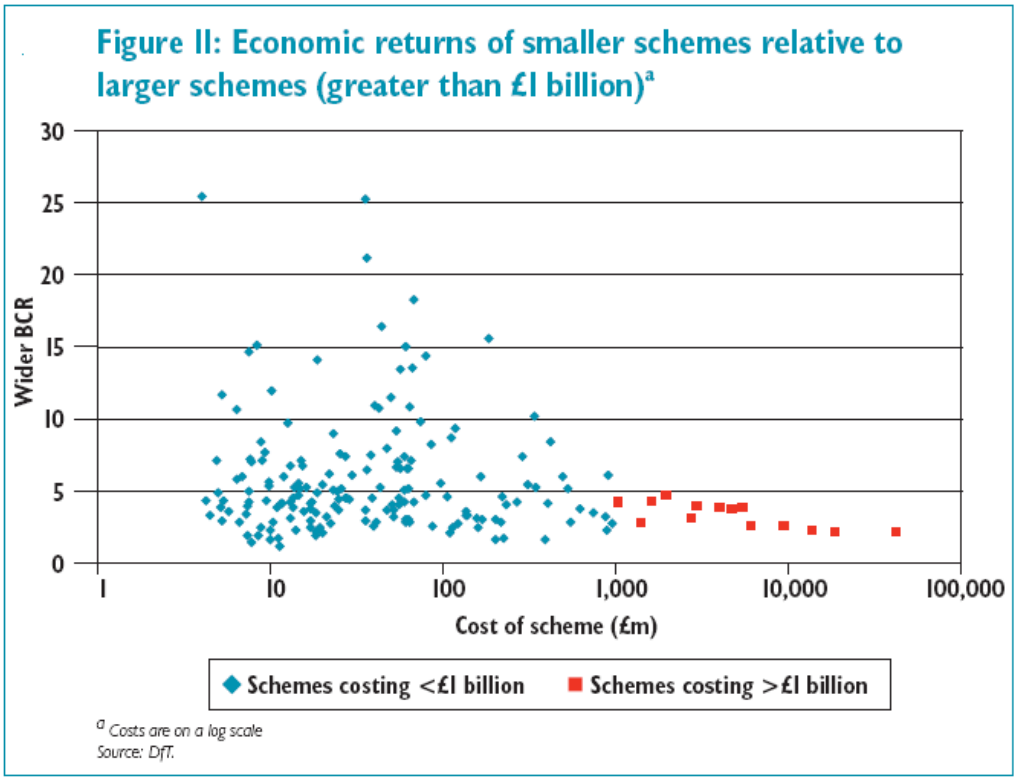
- Despite the effects generally being negative (and so reducing the reported BCR), there are some urban network projects which do provide social and environmental benefits that equate to additional value being added to the BCR resulting in a higher level of return.



Source of chart: DFT, The Eddington Transport Study

Overall the economic returns on a project vary significantly as is show below (economic returns against scheme size), however it is clear that smaller schemes

can provide a greater return than that of larger projects. This is because smaller projects will generally address bottlenecks or constraints within the system allowing for significant improvements in operation relative to the low investment requirement.



Source of chart: DFT, The Eddington Transport Study

The Eddington Transport Study, adds further weight to the case studies with similar rates of returns being reported. It also provides some insight into the 'wider costs and benefits' which is important given that more projects are likely to require impact assessments within these areas.

In terms of targeting investment the report also demonstrates that directing funds to smaller 'congestion relieving' projects should provide more significant returns than that of large scale investment. Despite this it should be noted that larger projects still provide returns 2-5 times that of the initial investment, and unlike smaller projects they are more likely to secure, and substantially increase long term capacity.

Importantly as you continue to undertake smaller projects to make improvements (above and beyond the maintenance of the existing infrastructure) the returns to scale will fall as the 'most economically beneficial' projects have taken place'.

Eventually as the existing infrastructure reaches capacity, at this point the attractiveness and comparative return of larger projects will overtake those of smaller project and attract significant levels of investment. Ultimately achieving a balance of investment in long term capacity and congestion relief is vital to meet any future economic challenges.

Appendices

Appendix A – The Global Competitiveness Report 2009–2010

The Global Competitiveness Report 2009-2010[39], provides a wide variety of statistics, based upon both hard (national statistics) and soft (opinion survey) data. The responses for the infrastructure proportions of the report, provide a comparative positioning of the UK against other economies.

Pillars of competitiveness

Within their report infrastructure is considered the second of 12 pillars, which can be used to help judge the effectiveness and competitiveness of an economy.

"Extensive and efficient infrastructure is an essential driver of competitiveness. It is critical for ensuring the effective functioning of the economy, as it is an important factor determining the location of economic activity and the kinds of activities or sectors that can develop in a particular economy. Well-developed infrastructure reduces the effect of distance between regions, with the result of truly integrating the national market and connecting it at low cost to markets in other countries and regions. In addition, the quality and extensiveness of infrastructure networks significantly impact economic growth and reduce income inequalities and poverty in a variety of ways."

UK Rankings:

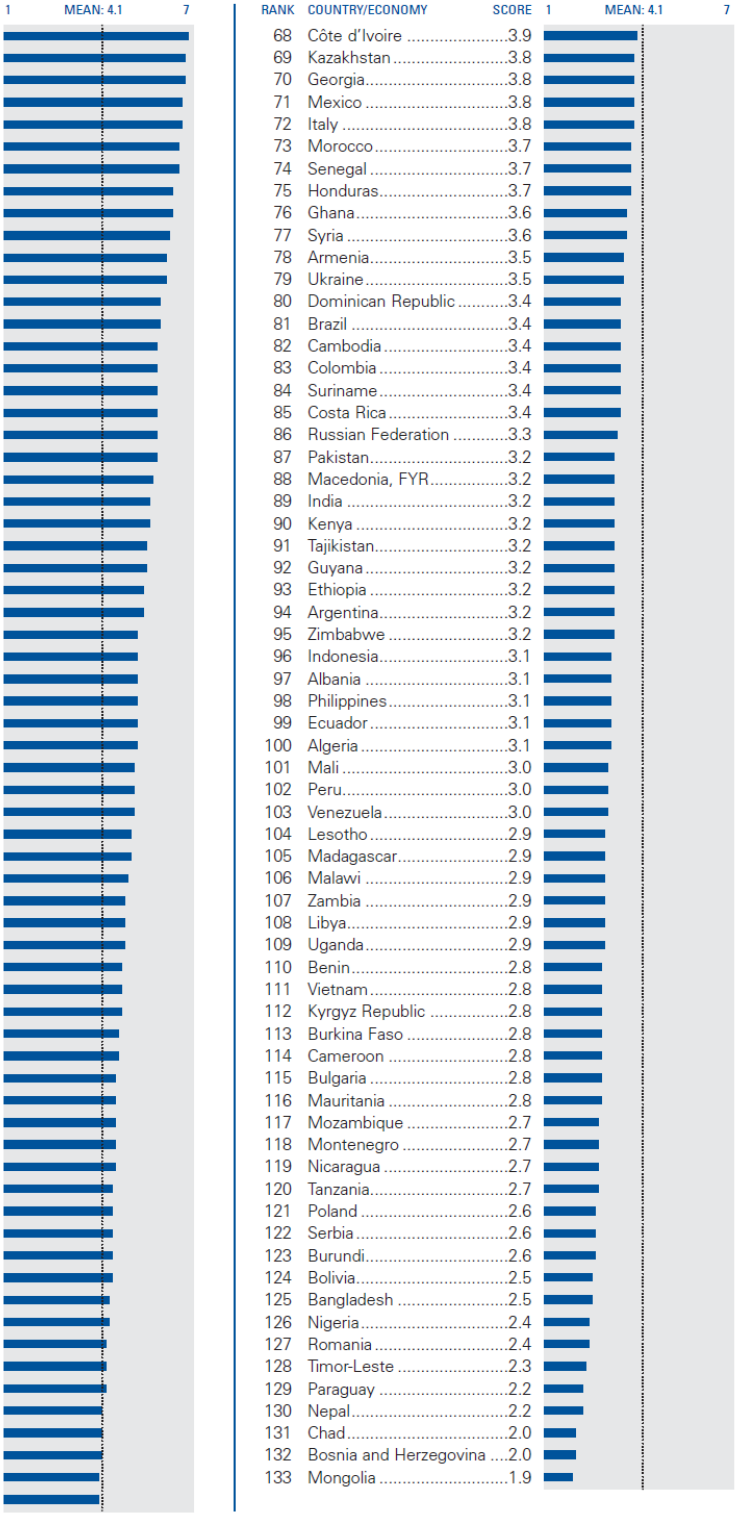
Quality of overall infrastructure	33rd
Quality of roads	30th
Quality of railroad infrastructure	21st
Quality of port infrastructure	31st
Quality of Air transport infrastructure	35th
Quality of electricity supply	18th

[39] The Global Competitiveness Report 2009-2010, World Economic Forum, http://www.weforum.org/en/initiatives/gcp/Global%20Competitiveness%20Report/index.htm

2.01 Quality of overall infrastructure

How would you assess general infrastructure (e.g., transport, telephony, and energy) in your country? (1 = extremely underdeveloped; 7 = extensive and efficient by international standards) | 2008–2009 weighted average

RANK	COUNTRY/ECONOMY	SCORE
1	Switzerland	6.8
2	Singapore	6.7
3	Hong Kong SAR	6.7
4	Austria	6.6
5	France	6.6
6	Germany	6.5
7	Finland	6.5
8	Iceland	6.3
9	Denmark	6.3
10	Sweden	6.2
11	United Arab Emirates	6.1
12	Luxembourg	6.1
13	Canada	5.9
14	United States	5.9
15	Belgium	5.8
16	Barbados	5.8
17	Japan	5.8
18	Netherlands	5.8
19	Taiwan, China	5.8
20	Korea, Rep.	5.8
21	Portugal	5.7
22	Oman	5.6
23	Chile	5.6
24	Cyprus	5.5
25	Namibia	5.5
26	Bahrain	5.4
27	Malaysia	5.4
28	Spain	5.2
29	Jordan	5.2
30	Slovenia	5.2
31	Norway	5.2
32	Saudi Arabia	5.2
33	United Kingdom	5.2
34	Estonia	5.1
35	Tunisia	5.1
36	Puerto Rico	5.1
37	Brunei Darussalam	5.0
38	Australia	5.0
39	Lithuania	4.9
40	El Salvador	4.8
41	Thailand	4.8
42	Malta	4.8
43	South Africa	4.7
44	Kuwait	4.7
45	New Zealand	4.7
46	Botswana	4.6
47	Qatar	4.6
48	Croatia	4.5
49	Gambia, The	4.5
50	Israel	4.5
51	Azerbaijan	4.5
52	Czech Republic	4.5
53	Mauritius	4.4
54	Greece	4.4
55	Jamaica	4.4
56	Egypt	4.4
57	Trinidad and Tobago	4.4
58	Hungary	4.3
59	Guatemala	4.3
60	Latvia	4.2
61	Uruguay	4.2
62	Turkey	4.2
63	Sri Lanka	4.1
64	Slovak Republic	4.1
65	Ireland	4.1
66	China	4.0
67	Panama	4.0
68	Côte d'Ivoire	3.9
69	Kazakhstan	3.8
70	Georgia	3.8
71	Mexico	3.8
72	Italy	3.8
73	Morocco	3.7
74	Senegal	3.7
75	Honduras	3.7
76	Ghana	3.6
77	Syria	3.6
78	Armenia	3.5
79	Ukraine	3.5
80	Dominican Republic	3.4
81	Brazil	3.4
82	Cambodia	3.4
83	Colombia	3.4
84	Suriname	3.4
85	Costa Rica	3.4
86	Russian Federation	3.3
87	Pakistan	3.2
88	Macedonia, FYR	3.2
89	India	3.2
90	Kenya	3.2
91	Tajikistan	3.2
92	Guyana	3.2
93	Ethiopia	3.2
94	Argentina	3.2
95	Zimbabwe	3.2
96	Indonesia	3.1
97	Albania	3.1
98	Philippines	3.1
99	Ecuador	3.1
100	Algeria	3.1
101	Mali	3.0
102	Peru	3.0
103	Venezuela	3.0
104	Lesotho	2.9
105	Madagascar	2.9
106	Malawi	2.9
107	Zambia	2.9
108	Libya	2.9
109	Uganda	2.9
110	Benin	2.8
111	Vietnam	2.8
112	Kyrgyz Republic	2.8
113	Burkina Faso	2.8
114	Cameroon	2.8
115	Bulgaria	2.8
116	Mauritania	2.8
117	Mozambique	2.7
118	Montenegro	2.7
119	Nicaragua	2.7
120	Tanzania	2.7
121	Poland	2.6
122	Serbia	2.6
123	Burundi	2.6
124	Bolivia	2.5
125	Bangladesh	2.5
126	Nigeria	2.4
127	Romania	2.4
128	Timor-Leste	2.3
129	Paraguay	2.2
130	Nepal	2.2
131	Chad	2.0
132	Bosnia and Herzegovina	2.0
133	Mongolia	1.9

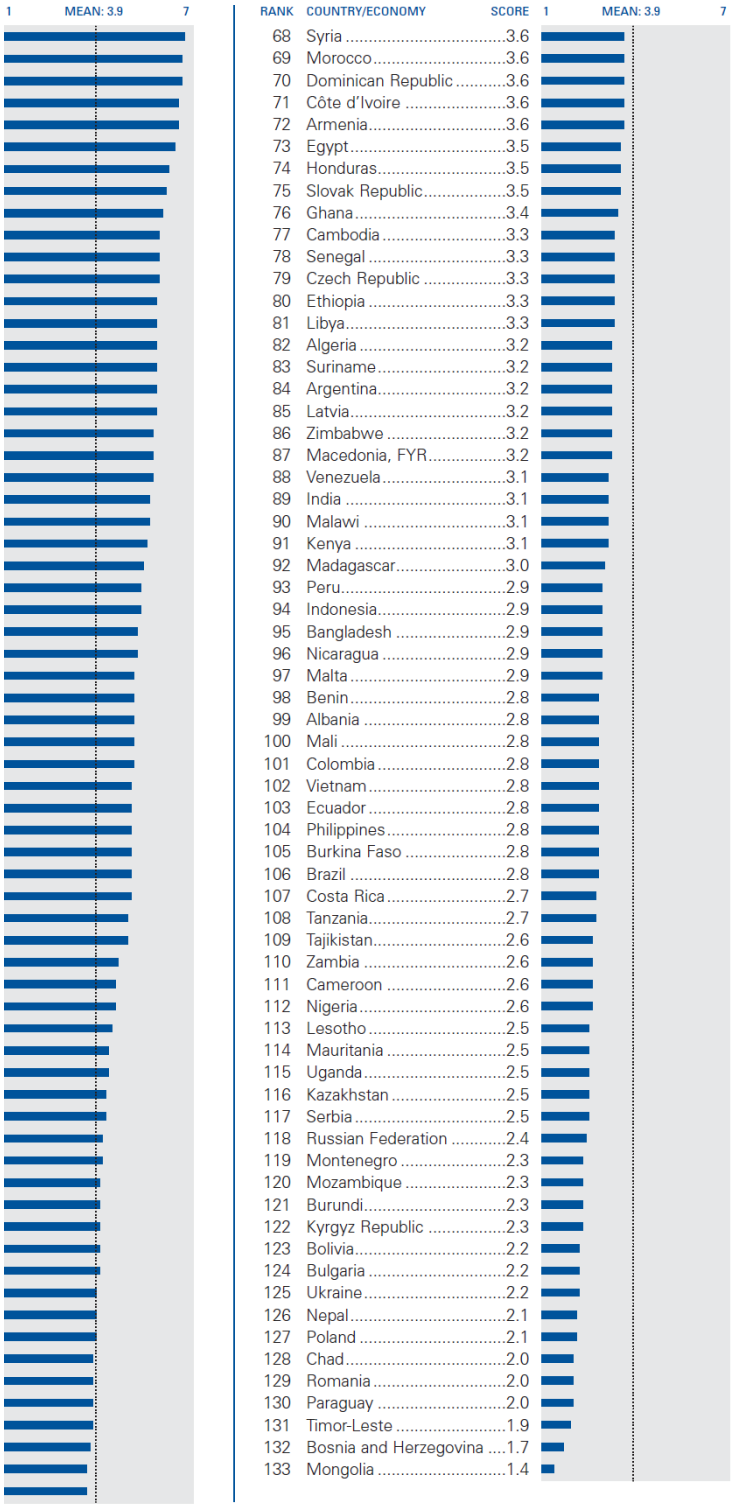


SOURCE: World Economic Forum, Executive Opinion Survey 2008, 2009

2.02 Quality of roads

How would you assess roads in your country? (1 = extremely underdeveloped; 7 = extensive and efficient by international standards) | 2008–2009 weighted average

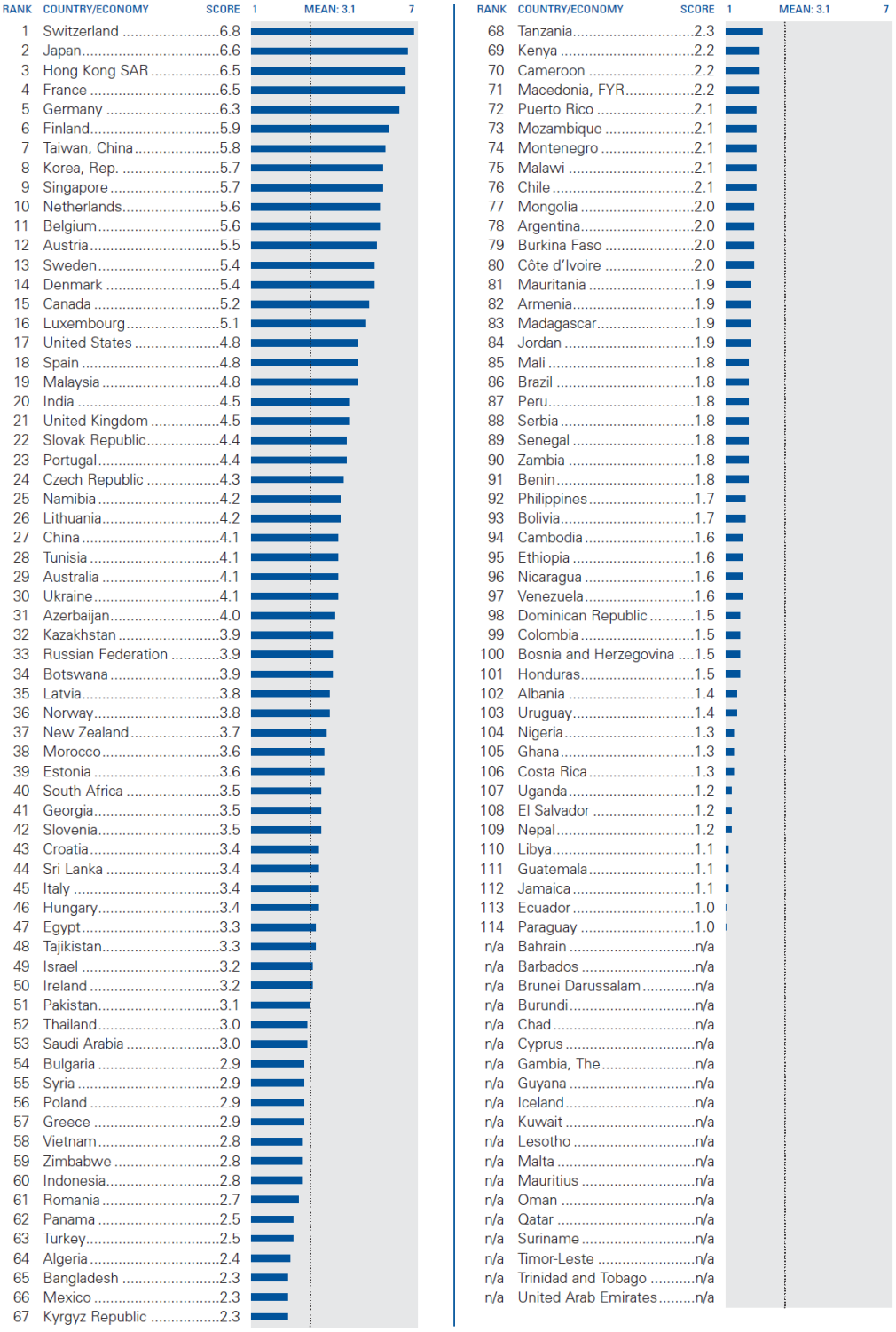
RANK	COUNTRY/ECONOMY	SCORE
1	Singapore	6.7
2	France	6.6
3	Hong Kong SAR	6.6
4	Switzerland	6.5
5	Germany	6.5
6	Austria	6.4
7	United Arab Emirates	6.2
8	Denmark	6.1
9	Portugal	6.0
10	Oman	5.9
11	United States	5.9
12	Finland	5.9
13	Cyprus	5.8
14	Korea, Rep.	5.8
15	Chile	5.8
16	Belgium	5.8
17	Luxembourg	5.8
18	Taiwan, China	5.8
19	Sweden	5.7
20	Namibia	5.7
21	Canada	5.7
22	Japan	5.6
23	Bahrain	5.6
24	Malaysia	5.5
25	Netherlands	5.4
26	Lithuania	5.3
27	El Salvador	5.3
28	Spain	5.2
29	Brunei Darussalam	5.2
30	United Kingdom	5.1
31	Puerto Rico	5.1
32	Barbados	5.1
33	Iceland	5.1
34	Croatia	5.1
35	Thailand	5.0
36	Kuwait	5.0
37	Australia	5.0
38	Saudi Arabia	5.0
39	Tunisia	5.0
40	South Africa	5.0
41	Slovenia	4.9
42	Jordan	4.9
43	New Zealand	4.6
44	Qatar	4.5
45	Botswana	4.5
46	Uruguay	4.4
47	Israel	4.3
48	Turkey	4.3
49	Estonia	4.2
50	China	4.2
51	Mauritius	4.1
52	Greece	4.1
53	Italy	4.0
54	Gambia, The	4.0
55	Guatemala	4.0
56	Trinidad and Tobago	4.0
57	Mexico	4.0
58	Azerbaijan	3.9
59	Ireland	3.9
60	Sri Lanka	3.9
61	Norway	3.8
62	Panama	3.8
63	Jamaica	3.8
64	Hungary	3.8
65	Pakistan	3.7
66	Georgia	3.6
67	Guyana	3.6
68	Syria	3.6
69	Morocco	3.6
70	Dominican Republic	3.6
71	Côte d'Ivoire	3.6
72	Armenia	3.6
73	Egypt	3.5
74	Honduras	3.5
75	Slovak Republic	3.5
76	Ghana	3.4
77	Cambodia	3.3
78	Senegal	3.3
79	Czech Republic	3.3
80	Ethiopia	3.3
81	Libya	3.3
82	Algeria	3.2
83	Suriname	3.2
84	Argentina	3.2
85	Latvia	3.2
86	Zimbabwe	3.2
87	Macedonia, FYR	3.2
88	Venezuela	3.1
89	India	3.1
90	Malawi	3.1
91	Kenya	3.1
92	Madagascar	3.0
93	Peru	2.9
94	Indonesia	2.9
95	Bangladesh	2.9
96	Nicaragua	2.9
97	Malta	2.9
98	Benin	2.8
99	Albania	2.8
100	Mali	2.8
101	Colombia	2.8
102	Vietnam	2.8
103	Ecuador	2.8
104	Philippines	2.8
105	Burkina Faso	2.8
106	Brazil	2.8
107	Costa Rica	2.7
108	Tanzania	2.7
109	Tajikistan	2.6
110	Zambia	2.6
111	Cameroon	2.6
112	Nigeria	2.6
113	Lesotho	2.5
114	Mauritania	2.5
115	Uganda	2.5
116	Kazakhstan	2.5
117	Serbia	2.5
118	Russian Federation	2.4
119	Montenegro	2.3
120	Mozambique	2.3
121	Burundi	2.3
122	Kyrgyz Republic	2.3
123	Bolivia	2.2
124	Bulgaria	2.2
125	Ukraine	2.2
126	Nepal	2.1
127	Poland	2.1
128	Chad	2.0
129	Romania	2.0
130	Paraguay	2.0
131	Timor-Leste	1.9
132	Bosnia and Herzegovina	1.7
133	Mongolia	1.4



SOURCE: World Economic Forum, Executive Opinion Survey 2008, 2009

2.03 Quality of railroad infrastructure

How would you assess the railroad system in your country? (1 = extremely underdeveloped; 7 = extensive and efficient by international standards) | 2008–2009 weighted average



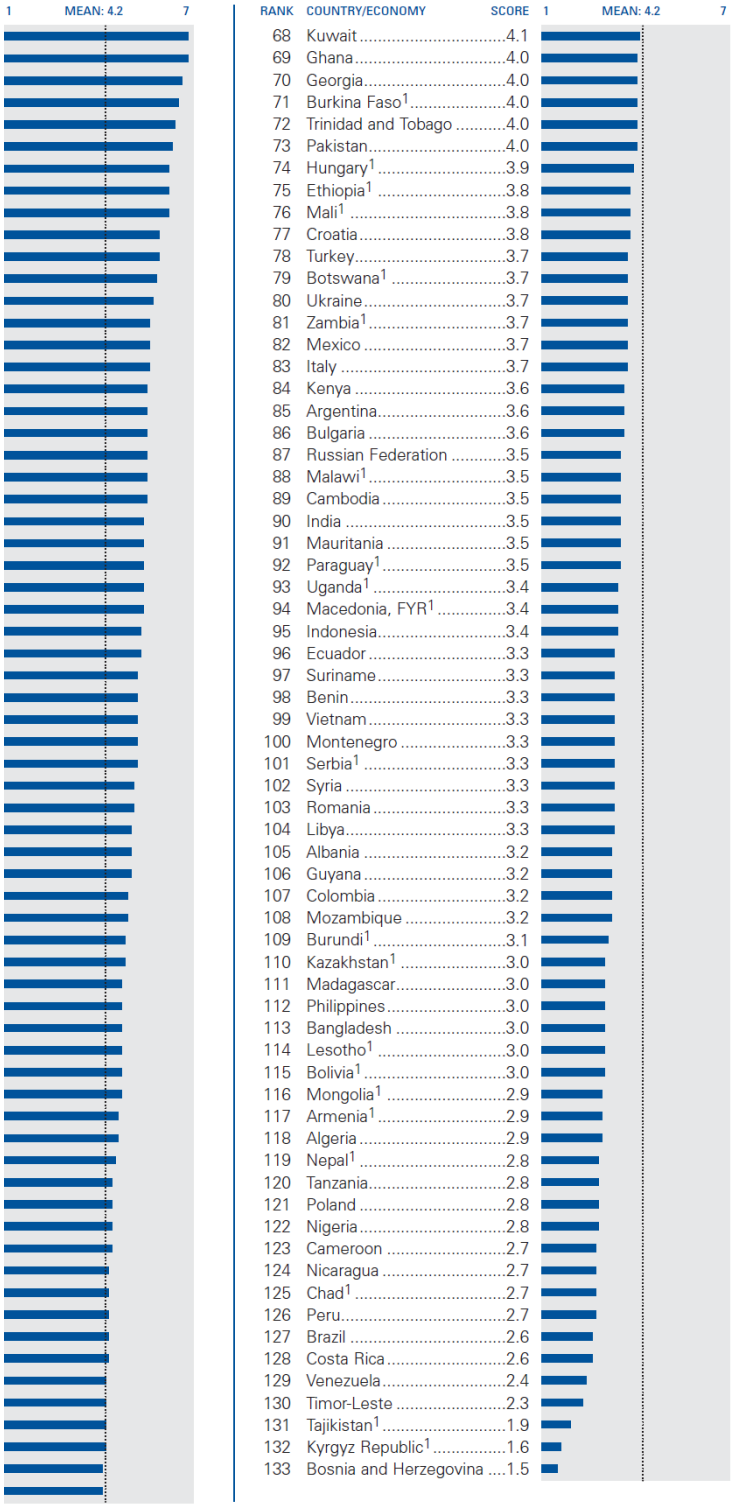
RANK	COUNTRY/ECONOMY	SCORE
1	Switzerland	6.8
2	Japan	6.6
3	Hong Kong SAR	6.5
4	France	6.5
5	Germany	6.3
6	Finland	5.9
7	Taiwan, China	5.8
8	Korea, Rep.	5.7
9	Singapore	5.7
10	Netherlands	5.6
11	Belgium	5.6
12	Austria	5.5
13	Sweden	5.4
14	Denmark	5.4
15	Canada	5.2
16	Luxembourg	5.1
17	United States	4.8
18	Spain	4.8
19	Malaysia	4.8
20	India	4.5
21	United Kingdom	4.5
22	Slovak Republic	4.4
23	Portugal	4.4
24	Czech Republic	4.3
25	Namibia	4.2
26	Lithuania	4.2
27	China	4.1
28	Tunisia	4.1
29	Australia	4.1
30	Ukraine	4.1
31	Azerbaijan	4.0
32	Kazakhstan	3.9
33	Russian Federation	3.9
34	Botswana	3.9
35	Latvia	3.8
36	Norway	3.8
37	New Zealand	3.7
38	Morocco	3.6
39	Estonia	3.6
40	South Africa	3.5
41	Georgia	3.5
42	Slovenia	3.5
43	Croatia	3.4
44	Sri Lanka	3.4
45	Italy	3.4
46	Hungary	3.4
47	Egypt	3.3
48	Tajikistan	3.3
49	Israel	3.2
50	Ireland	3.2
51	Pakistan	3.1
52	Thailand	3.0
53	Saudi Arabia	3.0
54	Bulgaria	2.9
55	Syria	2.9
56	Poland	2.9
57	Greece	2.9
58	Vietnam	2.8
59	Zimbabwe	2.8
60	Indonesia	2.8
61	Romania	2.7
62	Panama	2.5
63	Turkey	2.5
64	Algeria	2.4
65	Bangladesh	2.3
66	Mexico	2.3
67	Kyrgyz Republic	2.3
68	Tanzania	2.3
69	Kenya	2.2
70	Cameroon	2.2
71	Macedonia, FYR	2.2
72	Puerto Rico	2.1
73	Mozambique	2.1
74	Montenegro	2.1
75	Malawi	2.1
76	Chile	2.1
77	Mongolia	2.0
78	Argentina	2.0
79	Burkina Faso	2.0
80	Côte d'Ivoire	2.0
81	Mauritania	1.9
82	Armenia	1.9
83	Madagascar	1.9
84	Jordan	1.9
85	Mali	1.8
86	Brazil	1.8
87	Peru	1.8
88	Serbia	1.8
89	Senegal	1.8
90	Zambia	1.8
91	Benin	1.8
92	Philippines	1.7
93	Bolivia	1.7
94	Cambodia	1.6
95	Ethiopia	1.6
96	Nicaragua	1.6
97	Venezuela	1.6
98	Dominican Republic	1.5
99	Colombia	1.5
100	Bosnia and Herzegovina	1.5
101	Honduras	1.5
102	Albania	1.4
103	Uruguay	1.4
104	Nigeria	1.3
105	Ghana	1.3
106	Costa Rica	1.3
107	Uganda	1.2
108	El Salvador	1.2
109	Nepal	1.2
110	Libya	1.1
111	Guatemala	1.1
112	Jamaica	1.1
113	Ecuador	1.0
114	Paraguay	1.0
n/a	Bahrain	n/a
n/a	Barbados	n/a
n/a	Brunei Darussalam	n/a
n/a	Burundi	n/a
n/a	Chad	n/a
n/a	Cyprus	n/a
n/a	Gambia, The	n/a
n/a	Guyana	n/a
n/a	Iceland	n/a
n/a	Kuwait	n/a
n/a	Lesotho	n/a
n/a	Malta	n/a
n/a	Mauritius	n/a
n/a	Oman	n/a
n/a	Qatar	n/a
n/a	Suriname	n/a
n/a	Timor-Leste	n/a
n/a	Trinidad and Tobago	n/a
n/a	United Arab Emirates	n/a

SOURCE: World Economic Forum, Executive Opinion Survey 2008, 2009

2.04 Quality of port infrastructure

How would you assess port facilities in your country? (1 = extremely underdeveloped; 7 = well developed and efficient by international standards)* | 2008–2009 weighted average

RANK	COUNTRY/ECONOMY	SCORE
1	Singapore	6.8
2	Hong Kong SAR	6.8
3	Netherlands	6.6
4	Finland	6.5
5	Germany	6.4
6	Belgium	6.3
7	United Arab Emirates	6.2
8	Iceland	6.2
9	Denmark	6.2
10	France	5.9
11	Sweden	5.9
12	Norway	5.8
13	United States	5.7
14	Canada	5.6
15	Estonia	5.6
16	Taiwan, China	5.6
17	Bahrain	5.5
18	Panama	5.5
19	Malaysia	5.5
20	Luxembourg[1]	5.5
21	Barbados	5.5
22	New Zealand	5.5
23	Malta	5.4
24	Namibia	5.4
25	Puerto Rico	5.4
26	Switzerland[1]	5.4
27	Chile	5.4
28	Jamaica	5.3
29	Cyprus	5.3
30	Slovenia	5.2
31	United Kingdom	5.2
32	Oman	5.2
33	Spain	5.2
34	Japan	5.2
35	Honduras	5.1
36	Korea, Rep.	5.1
37	Qatar	5.0
38	Austria[1]	5.0
39	Côte d'Ivoire	5.0
40	Uruguay	4.9
41	Tunisia	4.9
42	Brunei Darussalam	4.8
43	Sri Lanka	4.8
44	Lithuania	4.7
45	Portugal	4.7
46	Saudi Arabia	4.7
47	Thailand	4.7
48	Gambia, The	4.7
49	South Africa	4.7
50	Australia	4.6
51	Israel	4.6
52	Jordan	4.5
53	Ireland	4.4
54	Senegal	4.4
55	Zimbabwe[1]	4.4
56	Latvia	4.4
57	Egypt	4.3
58	Dominican Republic	4.3
59	Guatemala	4.3
60	Mauritius	4.3
61	China	4.3
62	Morocco	4.2
63	Azerbaijan[1]	4.2
64	El Salvador	4.2
65	Czech Republic[1]	4.2
66	Greece	4.1
67	Slovak Republic[1]	4.1
68	Kuwait	4.1
69	Ghana	4.0
70	Georgia	4.0
71	Burkina Faso[1]	4.0
72	Trinidad and Tobago	4.0
73	Pakistan	4.0
74	Hungary[1]	3.9
75	Ethiopia[1]	3.8
76	Mali[1]	3.8
77	Croatia	3.8
78	Turkey	3.7
79	Botswana[1]	3.7
80	Ukraine	3.7
81	Zambia[1]	3.7
82	Mexico	3.7
83	Italy	3.7
84	Kenya	3.6
85	Argentina	3.6
86	Bulgaria	3.6
87	Russian Federation	3.5
88	Malawi[1]	3.5
89	Cambodia	3.5
90	India	3.5
91	Mauritania	3.5
92	Paraguay[1]	3.5
93	Uganda[1]	3.4
94	Macedonia, FYR[1]	3.4
95	Indonesia	3.4
96	Ecuador	3.3
97	Suriname	3.3
98	Benin	3.3
99	Vietnam	3.3
100	Montenegro	3.3
101	Serbia[1]	3.3
102	Syria	3.3
103	Romania	3.3
104	Libya	3.3
105	Albania	3.2
106	Guyana	3.2
107	Colombia	3.2
108	Mozambique	3.2
109	Burundi[1]	3.1
110	Kazakhstan[1]	3.0
111	Madagascar	3.0
112	Philippines	3.0
113	Bangladesh	3.0
114	Lesotho[1]	3.0
115	Bolivia[1]	3.0
116	Mongolia[1]	2.9
117	Armenia[1]	2.9
118	Algeria	2.9
119	Nepal[1]	2.8
120	Tanzania	2.8
121	Poland	2.8
122	Nigeria	2.8
123	Cameroon	2.7
124	Nicaragua	2.7
125	Chad[1]	2.7
126	Peru	2.7
127	Brazil	2.6
128	Costa Rica	2.6
129	Venezuela	2.4
130	Timor-Leste	2.3
131	Tajikistan[1]	1.9
132	Kyrgyz Republic[1]	1.6
133	Bosnia and Herzegovina	1.5



SOURCE: World Economic Forum, Executive Opinion Survey 2008, 2009

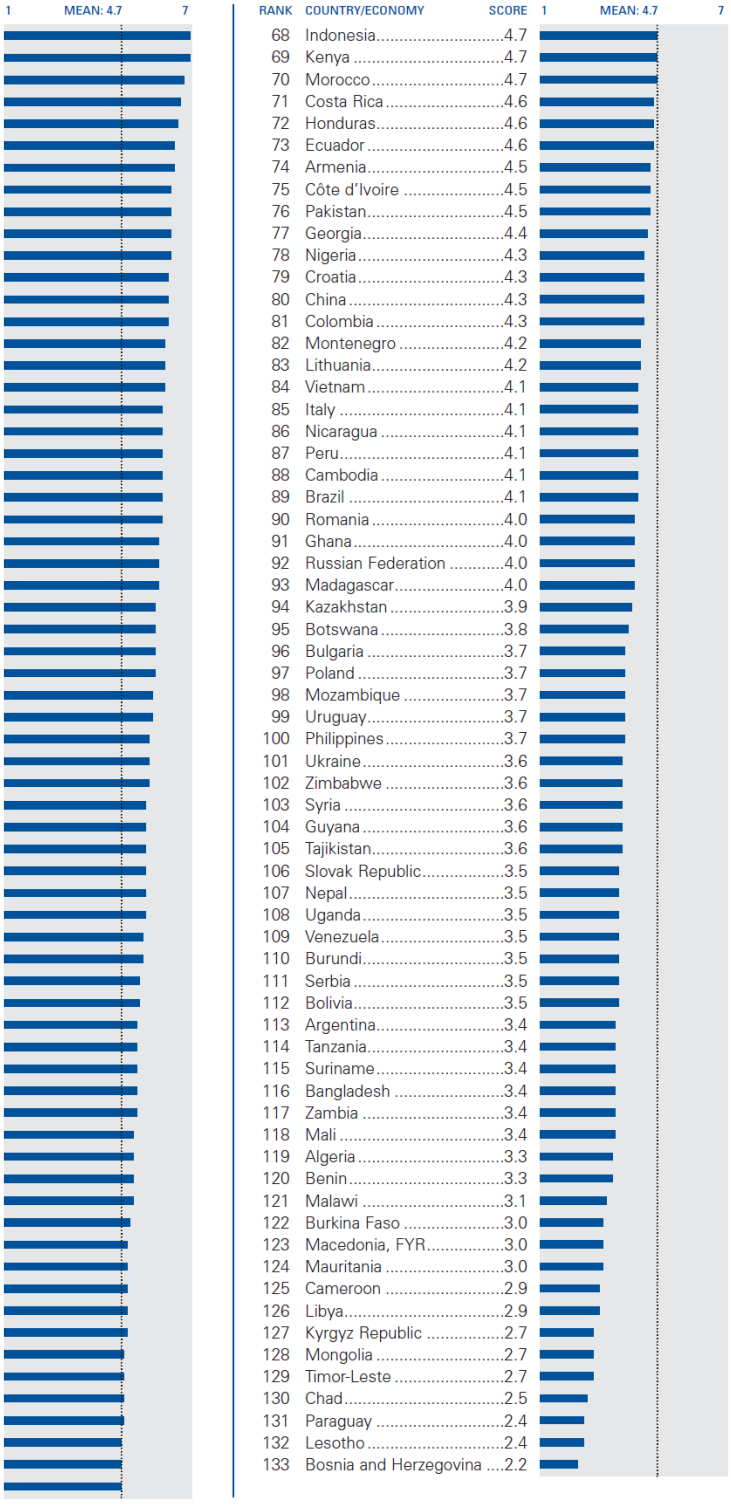
* For landlocked countries, the question is: How accessible are port facilities? (1 = extremely inaccessible; 7 = extremely accessible)

[1] Landlocked

2.05 Quality of air transport infrastructure

How would you assess passenger air transport infrastructure in your country? (1 = extremely underdeveloped; 7 = extensive and efficient by international standards) | 2008–2009 weighted average

RANK	COUNTRY/ECONOMY	SCORE
1	Singapore	6.9
2	Hong Kong SAR	6.9
3	United Arab Emirates	6.7
4	Germany	6.6
5	Switzerland	6.5
6	Denmark	6.4
7	Netherlands	6.4
8	Finland	6.3
9	France	6.3
10	Iceland	6.3
11	Norway	6.3
12	Qatar	6.2
13	Austria	6.2
14	Belgium	6.2
15	Puerto Rico	6.1
16	Barbados	6.1
17	New Zealand	6.1
18	Sweden	6.0
19	Chile	6.0
20	United States	6.0
21	Korea, Rep.	6.0
22	Bahrain	6.0
23	South Africa	6.0
24	Czech Republic	5.9
25	Canada	5.9
26	Thailand	5.9
27	Malaysia	5.8
28	Australia	5.8
29	El Salvador	5.8
30	Tunisia	5.8
31	Malta	5.7
32	Panama	5.7
33	Jordan	5.6
34	Israel	5.6
35	United Kingdom	5.6
36	Dominican Republic	5.5
37	Spain	5.5
38	Jamaica	5.5
39	Greece	5.5
40	Latvia	5.5
41	Taiwan, China	5.5
42	Luxembourg	5.4
43	Cyprus	5.4
44	Egypt	5.3
45	Guatemala	5.3
46	Trinidad and Tobago	5.2
47	Brunei Darussalam	5.2
48	Ireland	5.2
49	Portugal	5.2
50	Azerbaijan	5.2
51	Saudi Arabia	5.1
52	Oman	5.1
53	Japan	5.1
54	Turkey	5.1
55	Namibia	5.0
56	Mexico	4.9
57	Mauritius	4.9
58	Kuwait	4.9
59	Estonia	4.9
60	Slovenia	4.9
61	Gambia, The	4.8
62	Hungary	4.8
63	Albania	4.8
64	Sri Lanka	4.8
65	India	4.7
66	Senegal	4.7
67	Ethiopia	4.7
68	Indonesia	4.7
69	Kenya	4.7
70	Morocco	4.7
71	Costa Rica	4.6
72	Honduras	4.6
73	Ecuador	4.6
74	Armenia	4.5
75	Côte d'Ivoire	4.5
76	Pakistan	4.5
77	Georgia	4.4
78	Nigeria	4.3
79	Croatia	4.3
80	China	4.3
81	Colombia	4.3
82	Montenegro	4.2
83	Lithuania	4.2
84	Vietnam	4.1
85	Italy	4.1
86	Nicaragua	4.1
87	Peru	4.1
88	Cambodia	4.1
89	Brazil	4.1
90	Romania	4.0
91	Ghana	4.0
92	Russian Federation	4.0
93	Madagascar	4.0
94	Kazakhstan	3.9
95	Botswana	3.8
96	Bulgaria	3.7
97	Poland	3.7
98	Mozambique	3.7
99	Uruguay	3.7
100	Philippines	3.7
101	Ukraine	3.6
102	Zimbabwe	3.6
103	Syria	3.6
104	Guyana	3.6
105	Tajikistan	3.6
106	Slovak Republic	3.5
107	Nepal	3.5
108	Uganda	3.5
109	Venezuela	3.5
110	Burundi	3.5
111	Serbia	3.5
112	Bolivia	3.5
113	Argentina	3.4
114	Tanzania	3.4
115	Suriname	3.4
116	Bangladesh	3.4
117	Zambia	3.4
118	Mali	3.4
119	Algeria	3.3
120	Benin	3.3
121	Malawi	3.1
122	Burkina Faso	3.0
123	Macedonia, FYR	3.0
124	Mauritania	3.0
125	Cameroon	2.9
126	Libya	2.9
127	Kyrgyz Republic	2.7
128	Mongolia	2.7
129	Timor-Leste	2.7
130	Chad	2.5
131	Paraguay	2.4
132	Lesotho	2.4
133	Bosnia and Herzegovina	2.2

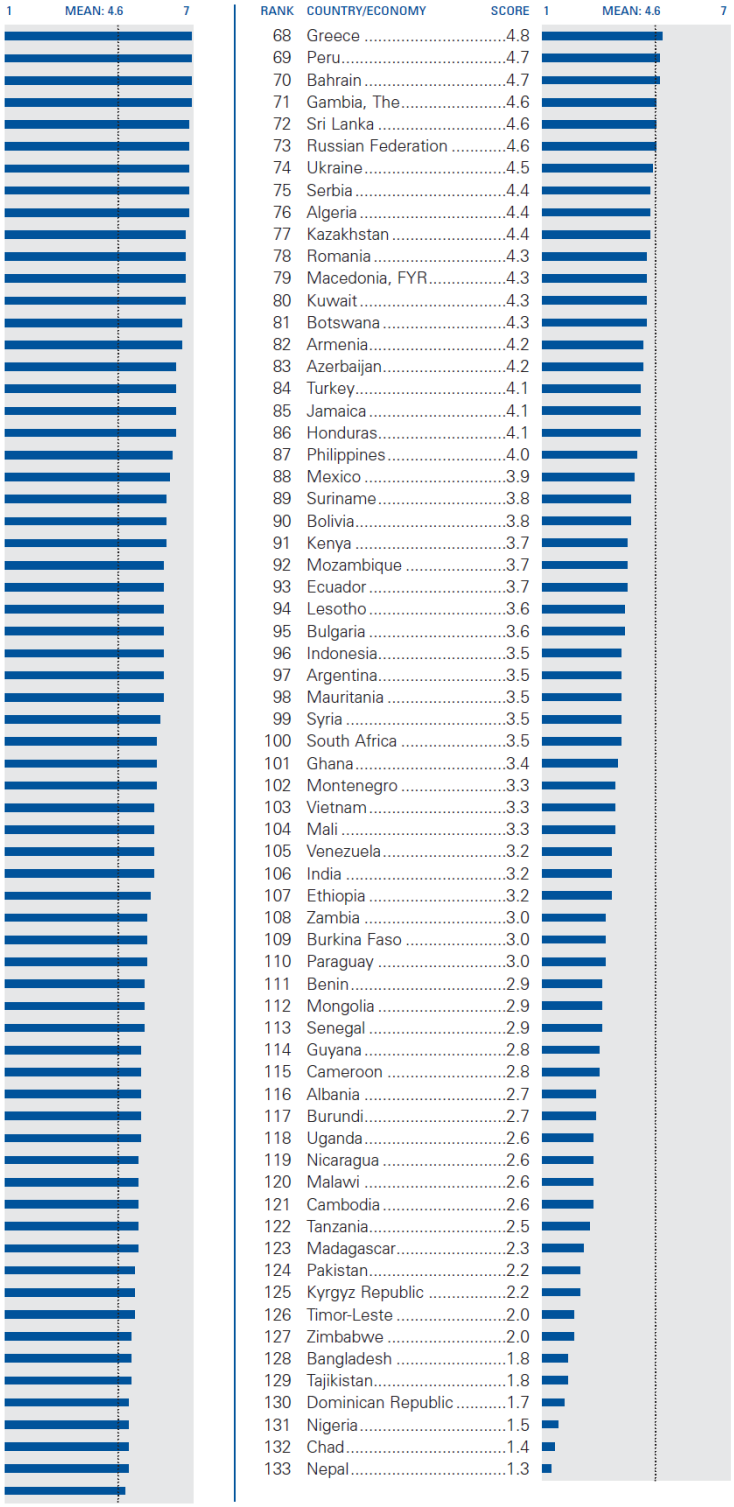


SOURCE: World Economic Forum, Executive Opinion Survey 2008, 2009

2.07 Quality of electricity supply

How does the quality of the electricity supply in your country (lack of interruptions and lack of voltage fluctuations) compare with that of other countries? (1 = worse than in most other countries; 7 = meets the highest standards in the world) | 2008–2009 weighted average

RANK	COUNTRY/ECONOMY	SCORE
1	Denmark	6.9
2	Iceland	6.9
3	Hong Kong SAR	6.9
4	Finland	6.9
5	France	6.8
6	Switzerland	6.8
7	Germany	6.8
8	Sweden	6.8
9	Netherlands	6.8
10	Austria	6.7
11	Japan	6.7
12	Singapore	6.7
13	Norway	6.7
14	Belgium	6.6
15	Canada	6.6
16	United Arab Emirates	6.4
17	United States	6.4
18	United Kingdom	6.4
19	Czech Republic	6.4
20	Luxembourg	6.3
21	Korea, Rep.	6.2
22	Portugal	6.1
23	Cyprus	6.1
24	Barbados	6.1
25	Qatar	6.0
26	Ireland	6.0
27	Slovak Republic	6.0
28	Australia	6.0
29	Oman	6.0
30	Israel	6.0
31	Slovenia	6.0
32	Taiwan, China	5.9
33	Saudi Arabia	5.8
34	Tunisia	5.8
35	Jordan	5.8
36	Uruguay	5.7
37	Chile	5.7
38	Estonia	5.7
39	Malaysia	5.7
40	Costa Rica	5.6
41	Thailand	5.5
42	Spain	5.5
43	Croatia	5.5
44	Lithuania	5.4
45	Italy	5.4
46	Bosnia and Herzegovina	5.4
47	Brunei Darussalam	5.3
48	Poland	5.3
49	Trinidad and Tobago	5.3
50	Latvia	5.3
51	Egypt	5.3
52	Hungary	5.2
53	New Zealand	5.2
54	Namibia	5.2
55	Brazil	5.2
56	Panama	5.2
57	Puerto Rico	5.1
58	Colombia	5.1
59	Mauritius	5.1
60	Morocco	5.0
61	China	5.0
62	El Salvador	5.0
63	Libya	4.9
64	Côte d'Ivoire	4.9
65	Guatemala	4.9
66	Georgia	4.9
67	Malta	4.8
68	Greece	4.8
69	Peru	4.7
70	Bahrain	4.7
71	Gambia, The	4.6
72	Sri Lanka	4.6
73	Russian Federation	4.6
74	Ukraine	4.5
75	Serbia	4.4
76	Algeria	4.4
77	Kazakhstan	4.4
78	Romania	4.3
79	Macedonia, FYR	4.3
80	Kuwait	4.3
81	Botswana	4.3
82	Armenia	4.2
83	Azerbaijan	4.2
84	Turkey	4.1
85	Jamaica	4.1
86	Honduras	4.1
87	Philippines	4.0
88	Mexico	3.9
89	Suriname	3.8
90	Bolivia	3.8
91	Kenya	3.7
92	Mozambique	3.7
93	Ecuador	3.7
94	Lesotho	3.6
95	Bulgaria	3.6
96	Indonesia	3.5
97	Argentina	3.5
98	Mauritania	3.5
99	Syria	3.5
100	South Africa	3.5
101	Ghana	3.4
102	Montenegro	3.3
103	Vietnam	3.3
104	Mali	3.3
105	Venezuela	3.2
106	India	3.2
107	Ethiopia	3.2
108	Zambia	3.0
109	Burkina Faso	3.0
110	Paraguay	3.0
111	Benin	2.9
112	Mongolia	2.9
113	Senegal	2.9
114	Guyana	2.8
115	Cameroon	2.8
116	Albania	2.7
117	Burundi	2.7
118	Uganda	2.6
119	Nicaragua	2.6
120	Malawi	2.6
121	Cambodia	2.6
122	Tanzania	2.5
123	Madagascar	2.3
124	Pakistan	2.2
125	Kyrgyz Republic	2.2
126	Timor-Leste	2.0
127	Zimbabwe	2.0
128	Bangladesh	1.8
129	Tajikistan	1.8
130	Dominican Republic	1.7
131	Nigeria	1.5
132	Chad	1.4
133	Nepal	1.3



SOURCE: World Economic Forum, Executive Opinion Survey 2008, 2009

Appendix B – UK public transport statistics

Trends across multiple transport types

Within the main report trends regarding the investment and usage of different types of transport infrastructure are undertaken. This appendix looks in more detail at usage trends amongst consumers for different types of transport and the level of public transport provision.

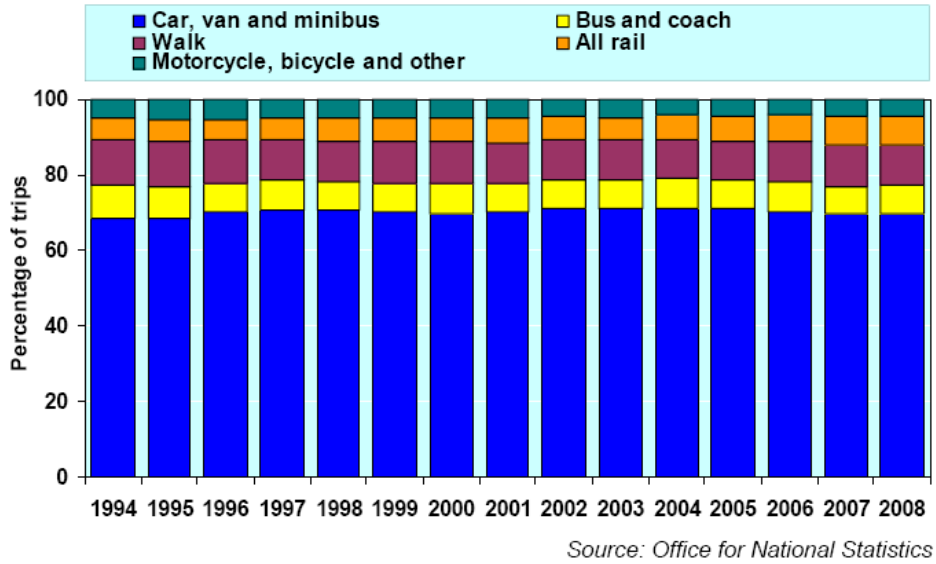
Within this cross-transportation analysis section of the appendix we draw on data and information from the following publication:

- Transport Trends 2009 Edition – The Department for Transport[40]

Capacity is important within transport infrastructure, and for sufficient planning and provision to occur, the various means of transport and their peak usage has to be taken into account.

Below are the the various methods of transport utilised during a persons travel to work (the majority of which will occur during the peak time periods).

Trend 4.6 – Main mode of travel to work: 1994 to 2008, Great Britain

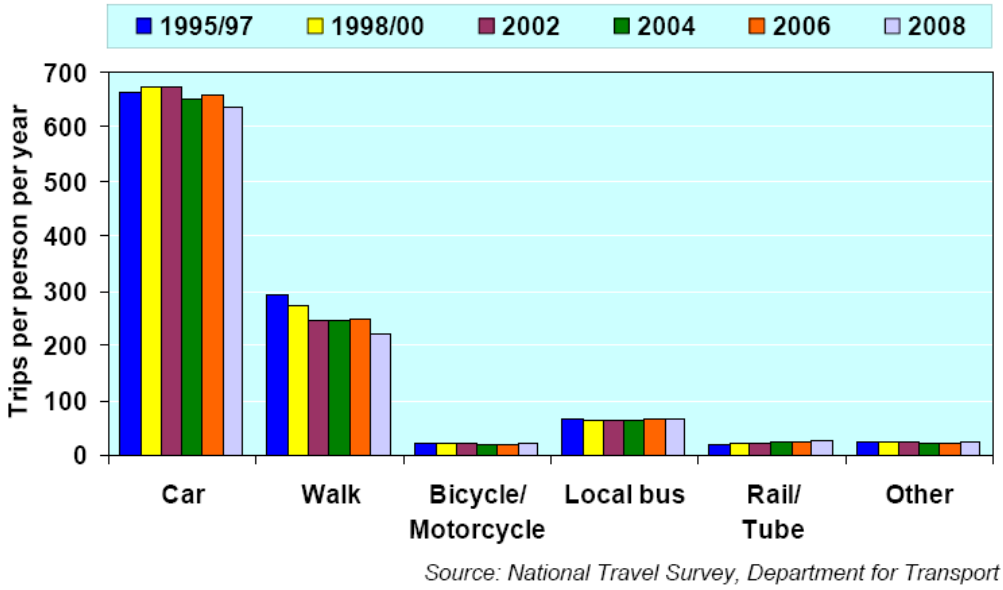


Source of chart: DFT, Transport Trends 2009 Edition

[40] Source: DFT, Transport Trends 2009 Edition, http://www.dft.gov.uk/adobepdf/162469/221412/190425/220778/trends2009.pdf

Despite there being a slight increase in the number of rail users generally it can be said that the method of transportation utilised by consumers has not varied significantly over the period. This is not necessarily unsurprising given that investment in areas such as the rail and road network will take time to feed through into everyday usage. Constraints such as space to provide improved infrastructure within cities also makes the task of providing public services increasingly difficult. For example, the Crossrail project mentioned in our case study has undergone multiple submissions designs and consultations before any work actually began.

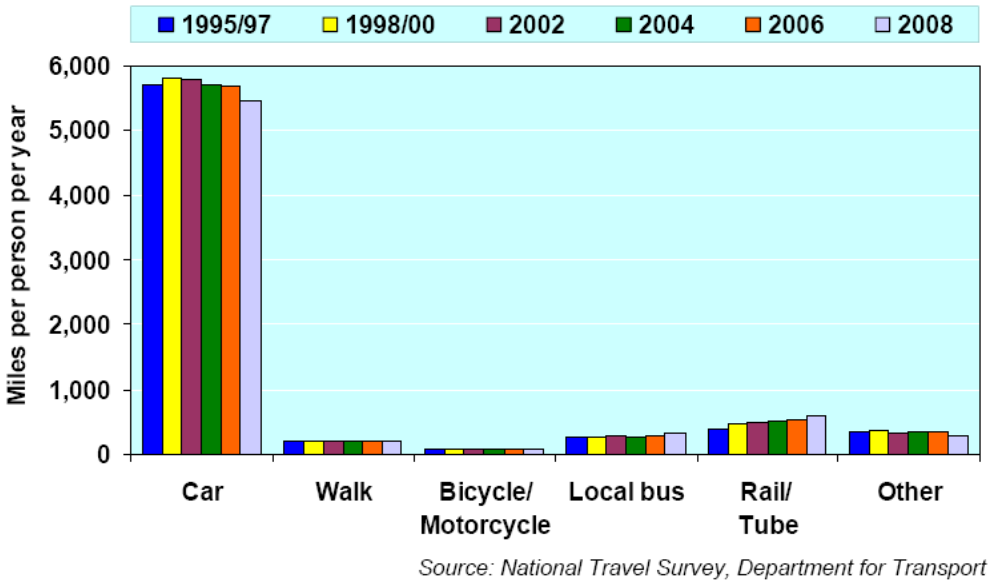
If we look at wider trends within transport (outside the constraint of peak travel) you find that although there has been a slight decline in usage (95/97 – 2008) the majority of trips still occur by car. This gives an indication as to how important the road network remains given that local buses also utilise the infrastructure that enables the provision of this activity.



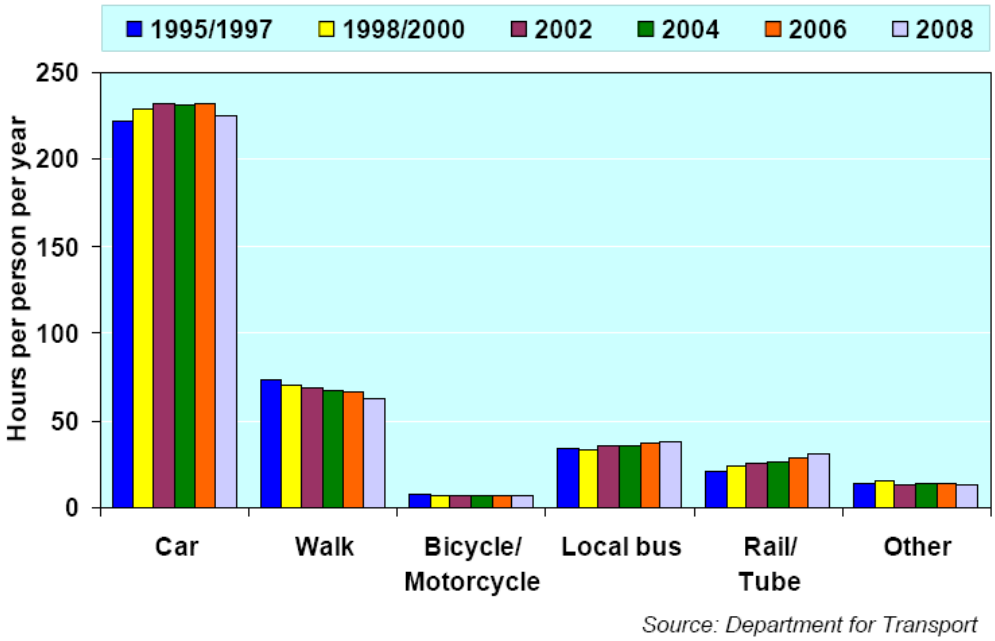
Source of chart: DFT, Transport Trends 2009 Edition

It is interesting to note that walking accounts for a significant number of trips overall, however this as a method of transport has been in decline (possibly due to slight increases in bicycle/motorcycle, bus and rail/tube utilisation).

The above statistics only account for the number of trips undertaken by the various forms of transport. It is also important to understand how these vary with regards to the distance travelled and the amount of time spent travelling.



Source of chart: DFT, Transport Trends 2009 Edition



Source of chart: DFT, Transport Trends 2009 Edition

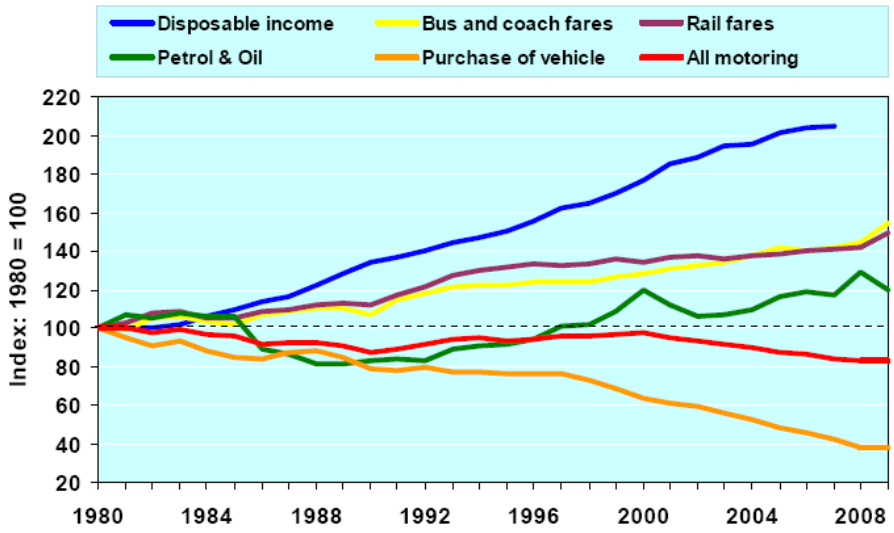
The above gives this information and as one would expect the car still accounts for the majority of the distance travelled and time spend travelling. Rail over the period has seen an increase in the distance travelled per person but so too has the time spent travelling. From this we can draw the conclusion that people are travelling further on the rail system more often so it occupies a larger amount of their time. The next question to ask is could we improve this? Projects such as

high speed rail which aim to improve productivity by increasing the distance travelled by rail whilst reducing the time taken would therefore be essential to improving the performance of the railway.

The same theory can be applied to the local bus network with the implementation of bus lanes improving the distance travelled whilst reducing the time taken for each journey.

As can be seen from the above, although the time spent on each form of transport is not per-say an indication of poor performance, we must strike the right balance between the distance travelled and the time taken, in other words the potential productivity gains generated by the network.

The above does not constitute the 'whole story' in terms of consumers selecting their method of transport. Although factors such as convenience, distance, quality and privacy all play their part, a significant determinate is that of price. Below is an index which compares the real costs of transport across the various methods of travel, with income in the UK.



Source of chart: DFT, Transport Trends 2009 Edition

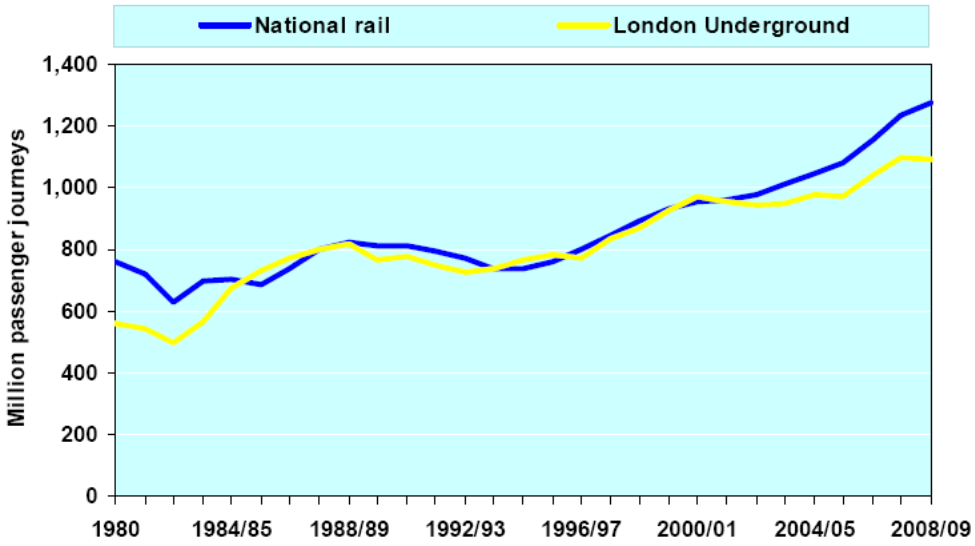
Over the period disposable income has continued to rise, and although the cost of running a motor vehicle has increased, this has been offset by a fall in the real cost of purchasing such a vehicle and so the overall the cost of motoring has fallen. In contrast to this the cost of rail, bus and coach fares have all increased over the period, making them less attractive to consumers.

Given the above it is important to analyse further the provision of public services on the road and railway in terms of service quality to see if anything could account for the relatively low level of usage and increasing real cost of service, when compared to private car usage.

Rail

First of all it is important to note that the number of rail journeys in the UK is increasing, which suggests the industry is improving. Given the rise in the real cost of providing rail services it is important that there is continued investment and value added in terms of the experience rail passengers receive.

Below is a more detailed plot of the number of passenger journeys that have occurred via national rail and London Underground since 1980.



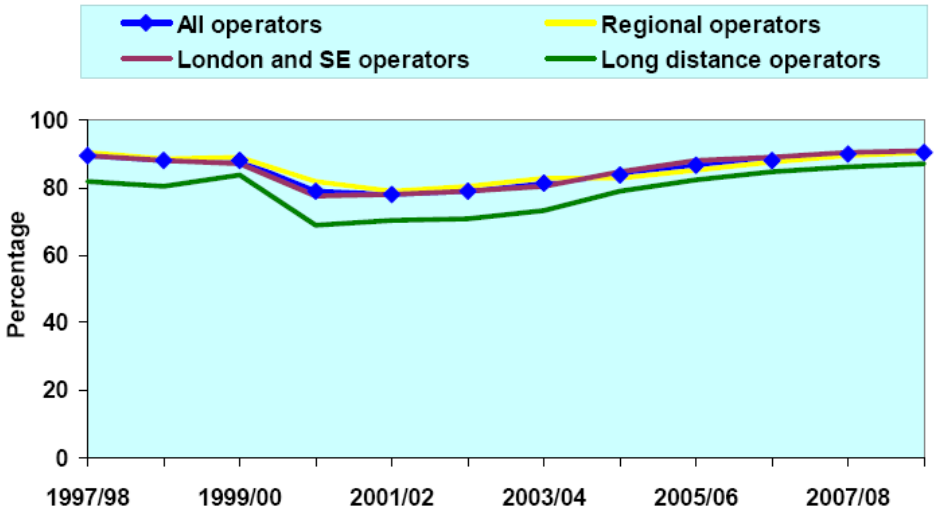
Data from 1984/85 are in financial years, prior to that calendar year data is shown.

Source: Office of Rail Regulation and Transport for London
The data in this chart are outside the scope of National Statistics

Source: Chart from DFT, Transport Trends 2009 Edition

As mentioned previously this suggests that the railways are improving, as the number of journeys are increasing, but has this been at the expense of service quality?

Using the statistics from the Transport Trends 2009 Edition we hope to further analyse the issues surrounding service quality and value for money in the hope of ascertaining whether consumers are getting a better service given the increase in real cost of rail travel.

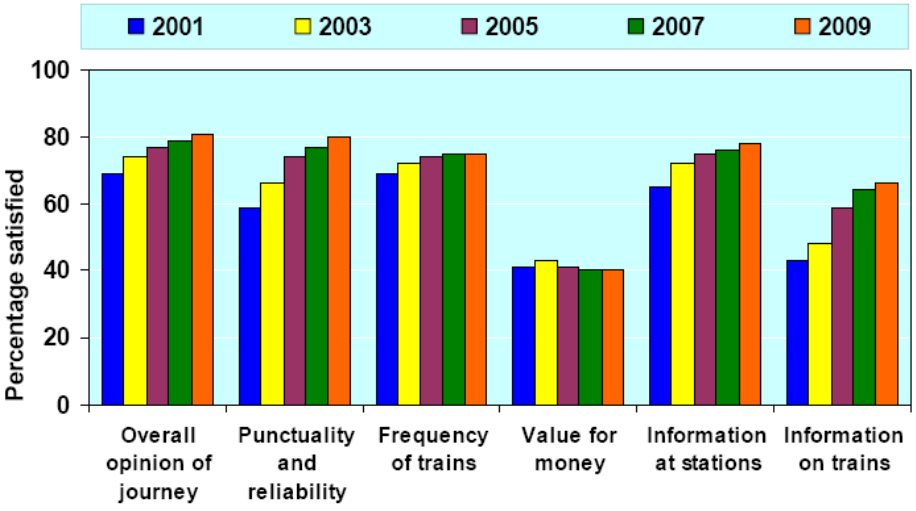


Source: Office of Rail Regulation
The data in this chart are outside the scope of National Statistics

Source of chart: DFT, Transport Trends 2009 Edition

The above chart plots the number of national rail trains arriving on time, and despite falling towards the end of the last recession, performance has continually increased since 2001.

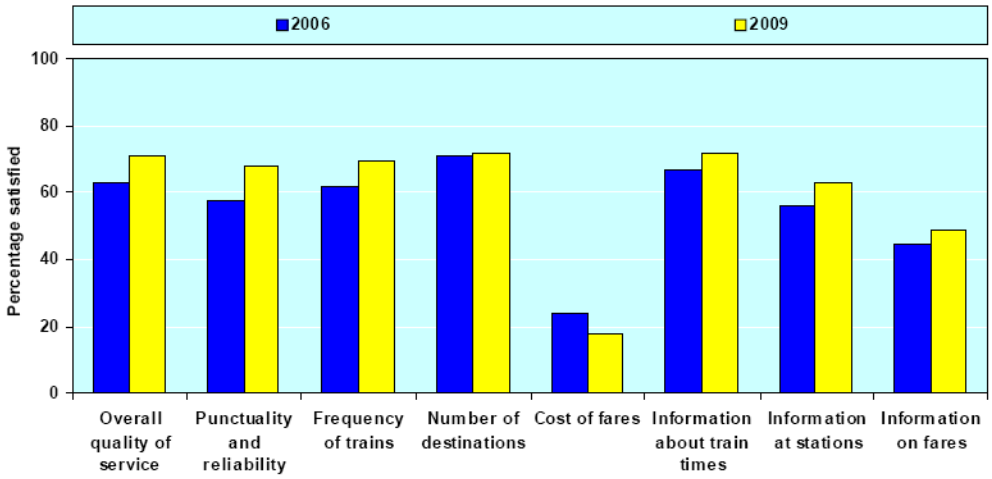
The financial crisis has not made the task of continuing to improve performance any simpler with credit constraints, and the UK's deficit likely to result in budget cuts. Both the Government and Network Rail are going to have to step up to the challenge of maintaining sufficient levels of spending upon railway infrastructure to ensure reliability.



Source: Passenger Focus (Rail Passengers Council)
The data in this chart are outside the scope of National Statistics

Source of chart: DFT, Transport Trends 2009 Edition

In terms of the provision of overall services, the railways have improved not only at national level (above) but also on then shorter intercity and regional routes (below). The only aspect which continues to be questioned by consumers is the value for money the railways provide. This also appears to be more of an issue on the shorter journeys with fewer than 20 percent of respondents indicating that the cost of fairs in their view was satisfactory.



Source: DfT: ONS Opinions Survey
The data in this chart are outside the scope of National Statistics

Source of chart: DFT, Transport Trends 2009 Edition

Shorter journeys generally have lower levels of satisfaction than those at a national level. When asked how these services could improve the top 5 reported responses were:

- Cost of fares
- Level of crowding
- Frequency of trains
- On board comfort
- Reliability/punctuality

The cost of fares does ultimately conflict with the ability to undertake activities to improvements the other measures. However, if services such as reliability/punctuality, frequency and comfort were to improve, whilst reducing the levels of overcrowding consumers may feel that the current fare is more justifiable.

This may mean that investment has to increasingly target projects that provide the greatest level of return and efficiency.

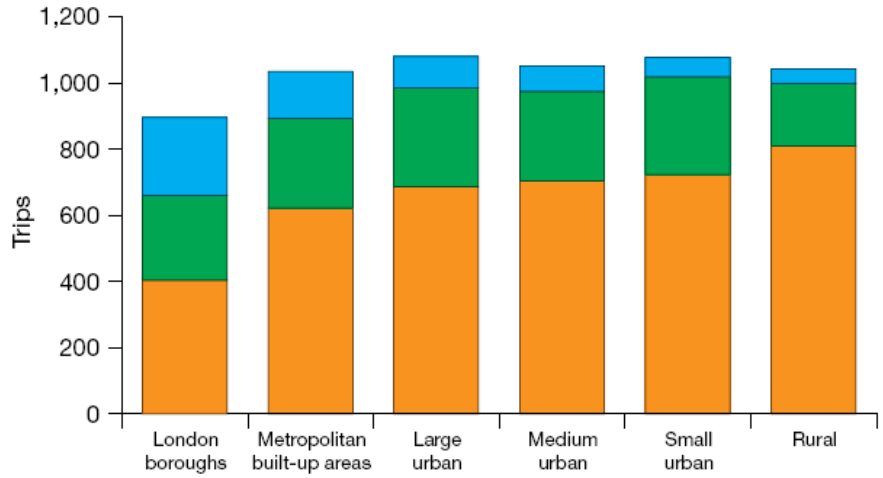
Road

As with the railways this report will look in more detail at public transport that utilises the road infrastructure in the UK. In addition to the Transport Trends 2009 report produced by the DFT, the following reports have been used:

- DFT, Roads – Delivering Choice and Reliability
- DFT, Bus and Light Rail Statistics GB: Q 4 2009

The breakdown below shows that the greatest level of public transport utilisation occurs in the London boroughs and metropolitan areas. It is no surprise that as the areas become more remote, the services less frequent and the potential distance travels increases that the number of users falls.

Figure 3: Trips per person per year by main mode and area type, Great Britain, 2005

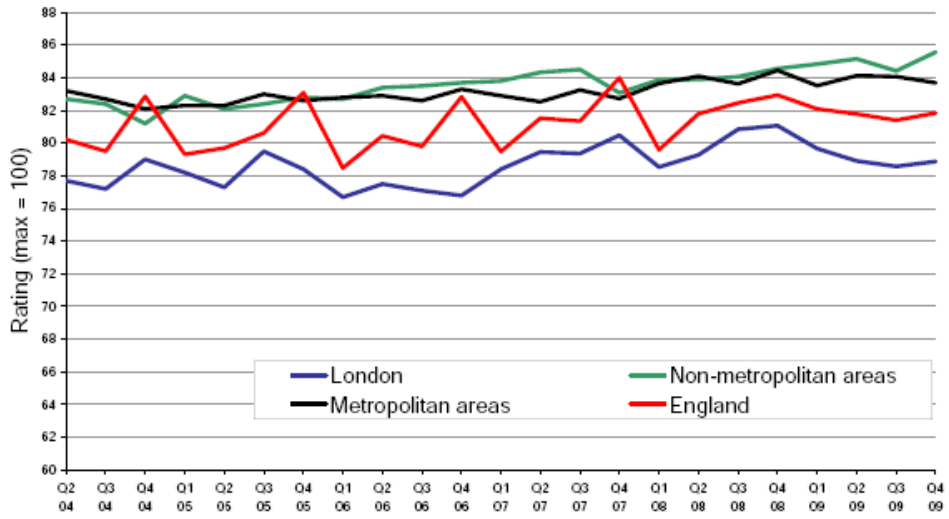


Source of chart: DFT, Roads – Delivering Choice and Reliability

Interestingly, the DFT measure of overall satisfaction for bus journeys (below) indicates that the least satisfied people are those in London, whereas the most satisfied are in non-metropolitan areas. This may be considered unusual at first glance given that the concentration and frequency of public services in built up areas is higher. However, congestion problems within cities such as London, could

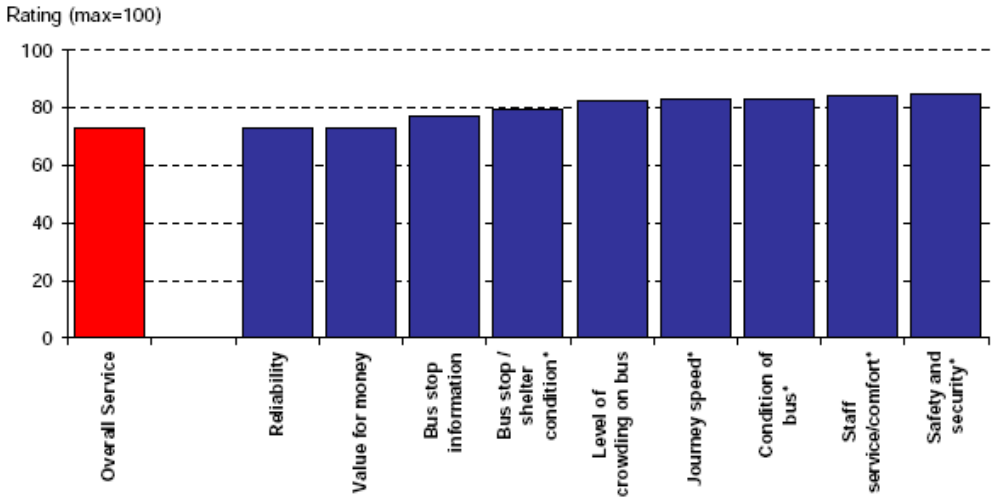
impact upon reliability, or there may possibly be some degree of bias within the sample sizes.

Figure 1.2: Bus passenger satisfaction rating: overall service



Source of chart: DFT, Bus and Light Rail Statistics GB: Q 4 2009

The rating for different aspects of service from the bus companies reveal that both value for money and reliability score low, followed bus stop information services and bus stop and shelter conditions.



Source of chart: DFT, Bus and Light Rail Statistics GB: Q 4 2009

This would appear to suggest that continued investment in information services and the infrastructure supporting the bus network is beneficial. For example in cities where unforeseen incidents may cause traffic issues information services allow bus network users to adapt their behaviour and possibly seek alternative

routes home. Although solving congestion issues should be a priority simply providing customers with relevant and up to date information will make their general experience much more satisfying.

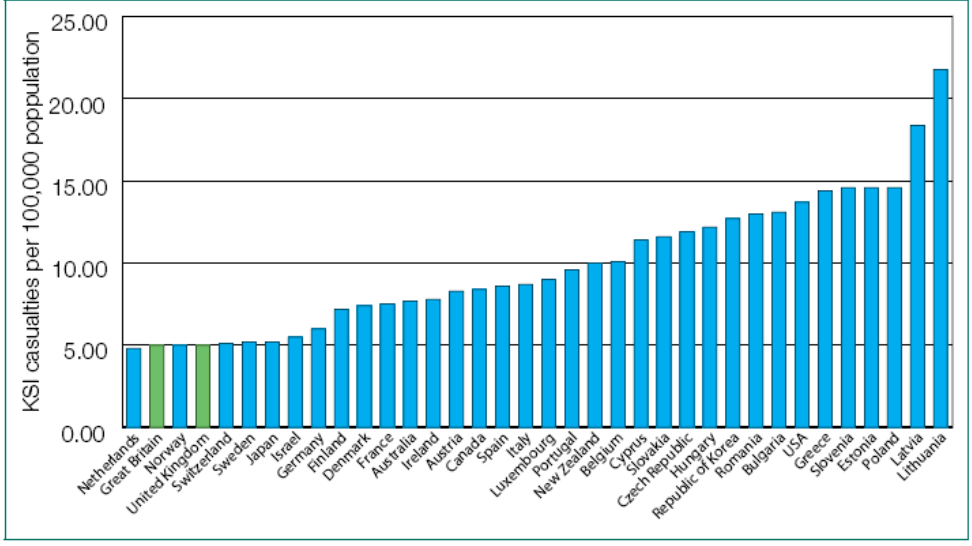
Appendix C – UK road safety

The Department for transport in April 2009 produced A Safer Way: Consultation on Making Britain's Roads the Safest in the World[41]. This document outlined the current statistics and challenges surrounding road safety and its target of reducing the number of deaths on our roads by one-third by 2020.

Given targets such as the above, investment in roads will to some extend consider or be guided by a willingness to improve not only quality but also safety.

Within the DFT report, there is a comparison of the UK to other countries on the issue of road safety. As demonstrated below by the fatality rate per 100,000 of population the UK performs well, however it is felt that further improvements can still be made.

Figure 2.2 International comparison* of fatality rate per 100,000 population 2007



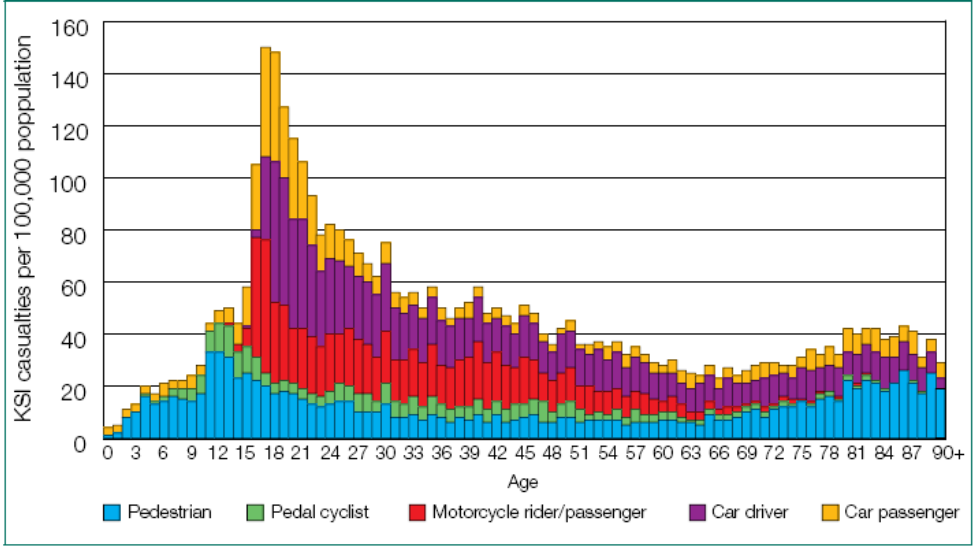
*Countries with a population of 500,000 or more
Source: International Road Traffic Accidents Database (IRTAD) and EU road traffic accident data (CARE)

Within the UK if we break down the number of killed or seriously injured (KSI) cases on the roads we discover that most incidents occur between the ages of 15 and 30, within both car and motorcycle drivers and passengers.

This unfortunately does not suggest that any particular form of investment may be useful in reducing these types of injuries.

[41] DFT - A Safer Way: Consultation on Making Britain's Roads the Safest in the World, http://www.dft.gov.uk/consultations/closed/roadsafetyconsultation/roadsafetyconsultation.pdf

Figure 2.6 KSI casualties per 100,000 population, by age and casualty type: GB, 2007



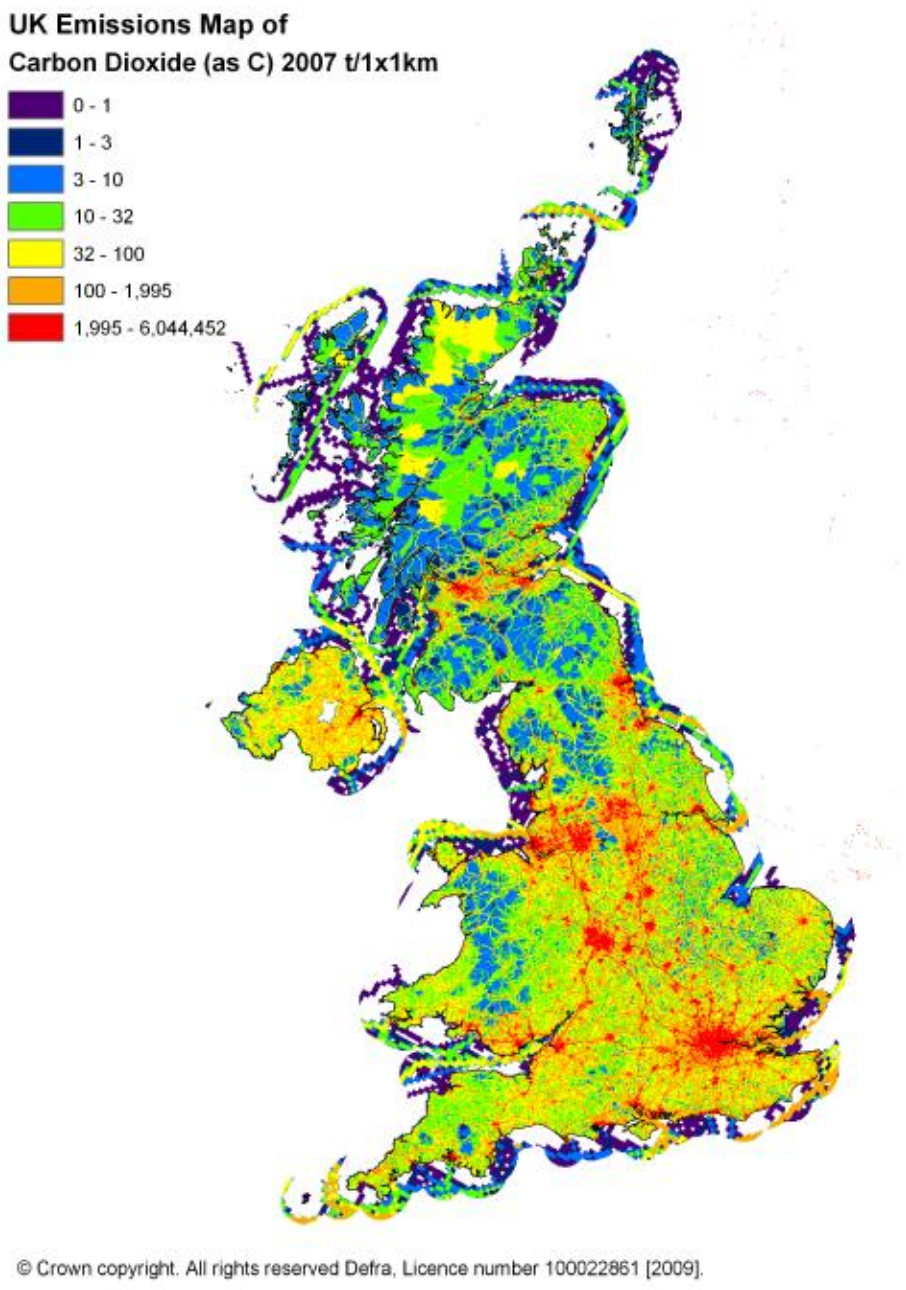
Source: STATS19

When looking specifically at the number of pedestrian KSI incidents, the rate rises amongst children and the elderly. Given that most pedestrians are likely to be within a short distance of home, or work this would infer that investment in traffic calming measures around schools and areas with a high concentration of elderly people could be effective in reducing KSI incidents within these groups.

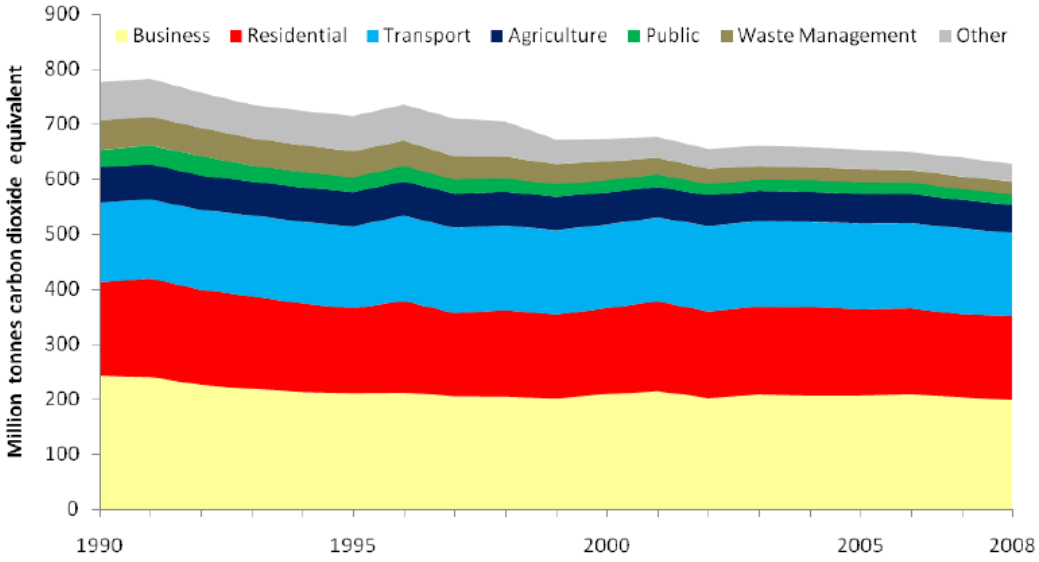
Appendix D – UK emissions and environmental

Increasingly infrastructure investment has to take account of and mitigate against its environmental impacts. Given the UK's target of a 80% reduction in carbon emissions by 2050, serious consideration is going to have to be given to how we invest in a way which is conducive to meeting this target.

The UK's carbon footprint



Source: AEA Local and Regional CO^2 Emissions Estimates for 2005 - 2007 for the UK – produced for DECC



Source: AEA 2008 GREENHOUSE GAS EMISSIONS, FINAL FIGURES BY END-USER – produced for DECC

As one would expect the level of carbon emissions is generally correlated with residential density and industry. Sectorial breakdowns reveal that business, residencies and transportation account for the majority of the UK's carbon emissions.

Businesses emissions have been falling since 1990, as environmental awareness and government policies take effect. This is in contrast to the household and transport sectors which have undergone little improvement.

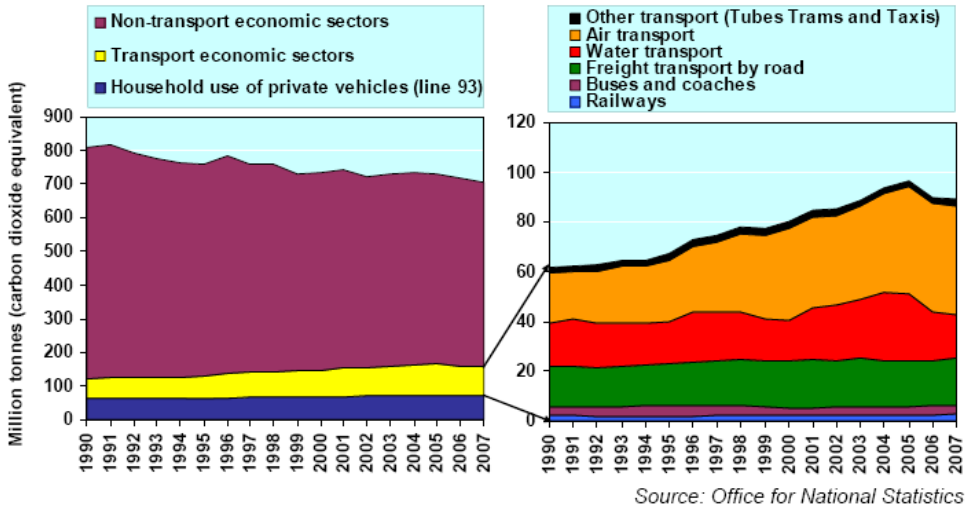
In terms of investment this means that policies need to be aimed at retrofitting the existing housing stock and improving energy efficiency. The transport sector unlike the housing sector has had to deal with a variety of legislation and taxation to encourage carbon emissions reductions.

The department for transport recently published its 'Transport Trends - 2009 Edition[42]' report in which the environmental footprint of the UK transportation system was outlined in further detail.

[42] Source: DFT , Transport Trends - 2009 Edition
http://www.dft.gov.uk/adobepdf/162469/221412/190425/220778/trends2009.pdf

Trend 8.5a – Greenhouse gas emissions by economic sector: 1990 to 2007, United Kingdom

Trend 8.5b – Greenhouse gas emissions from transport economic sectors: 1990 to 2007, United Kingdom



Source of chart: DFT

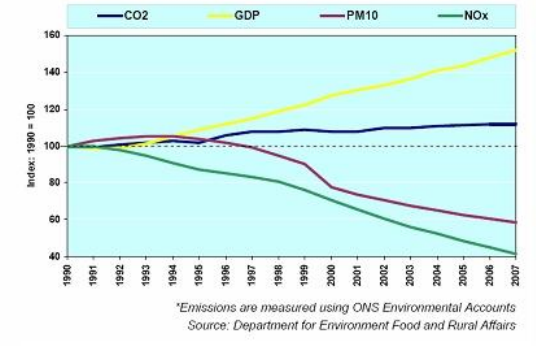
Transport can essentially be categorised into two distinct areas that of usage, private and public transport. Since 1997, private emissions have remained relatively stable, despite usage of private vehicles having risen. Improved performance of combustion engines, stricter regulations, a wider use of public transport, and increased environmental awareness have all helped to prevent emissions rising further. Public transport on the other hand has undergone a gradual increase in its level of carbon emissions; with the significant rise in the use of air travel being the contributing factor.

The DFT report also reveals that the rise in transport emissions has to some extent been decoupled from that of GDP and household expenditure. Generally as incomes rise individuals will go on a greater number of holidays, purchase more electrical goods, own an increasing number of vehicles with larger engine capacities and hence consume more energy.

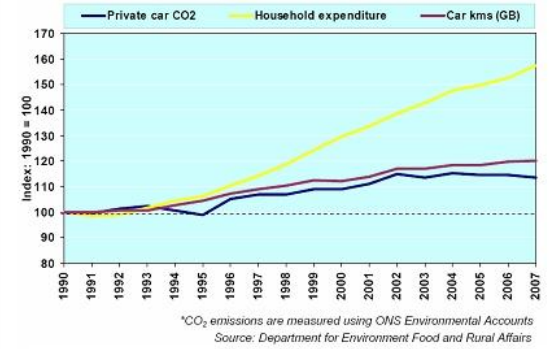
As environmental awareness has increases and legislation put in place it may eventually be the case that emissions fall as your income increases given that the individual has the funds to implement energy efficiency improvements and purchase products which have a better energy efficiency rating. Effectively the level of emissions savings due to such purchases would be greater than any emissions

increased due to the purchase of additional goods. Although this type of scenario may take a significant number of years to reach fruition.

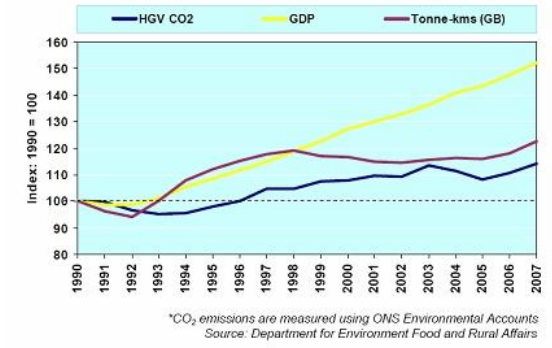
Trend 8.7a – Road transport CO_2, PM_{10}, NO_x emissions* and Gross Domestic Product: 1990 to 2007, United Kingdom



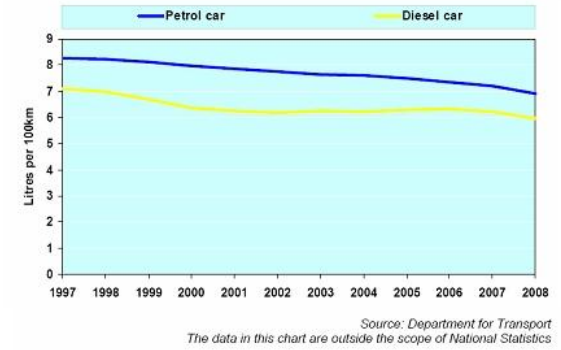
Trend 8.7b – Private car CO_2 emissions*, car kilometres and household expenditure: 1990 to 2007, United Kingdom



Trend 8.7c – Heavy Goods Vehicle (HGV) CO_2 emissions*, freight moved and Gross Domestic Product: 1990 to 2007, United Kingdom



Trend 8.8b – Average new car fuel consumption (Registration-weighted: petrol and diesel vehicles): 1997 to 2008, United Kingdom



Source of chart: DFT

Appendix E – Nomenclature of Units for Territorial Statistics

Further details on the exact specification of NUTS can be found on the Eurostat website.[43] The UK breakdown under the EU NUTS system can be found below:

NUTS203CD	NUTS203NM
UKC1	Tees Valley and Durham
UKC2	Northumberland and Tyne and Wear
UKD1	Cumbria
UKD2	Cheshire
UKD3	Greater Manchester
UKD4	Lancashire
UKD5	Merseyside
UKE1	East Riding and North Lincolnshire
UKE2	North Yorkshire
UKE3	South Yorkshire
UKE4	West Yorkshire
UKF1	Derbyshire and Nottinghamshire
UKF2	Leicestershire, Rutland and Northamptonshire
UKF3	Lincolnshire
UKG1	Herefordshire, Worcestershire and Warwickshire
UKG2	Shropshire and Staffordshire
UKG3	West Midlands
UKH1	East Anglia
UKH2	Bedfordshire and Hertfordshire
UKH3	Essex
UKI1	Inner London
UKI2	Outer London
UKJ1	Berkshire, Buckinghamshire and Oxfordshire
UKJ2	Surrey, East and West Sussex
UKJ3	Hampshire and Isle of Wight
UKJ4	Kent
UKK1	Gloucestershire, Wiltshire and North Somerset
UKK2	Dorset and Somerset
UKK3	Cornwall and Isles of Scilly
UKK4	Devon
UKN0	Northern Ireland
UKM1	North Eastern Scotland
UKM2	Eastern Scotland
UKM3	South Western Scotland
UKM4	Highlands and Islands
UKL1	West Wales and The Valleys
UKL2	East Wales

Source: ONS[44]

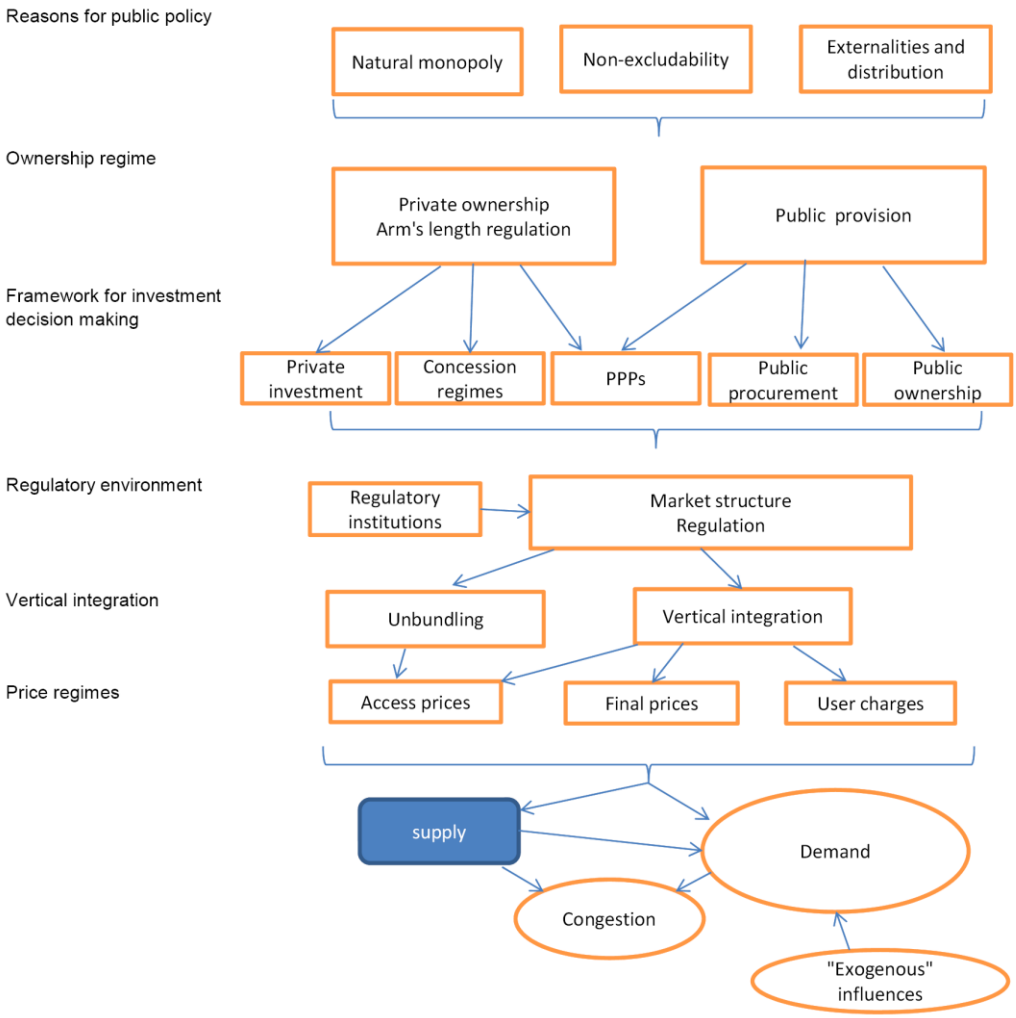
[43] Source: Eurostat - http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/regional_statistics/nuts_classification

[44] Source: ONS - http://www.statistics.gov.uk/geography/downloads/NUTS2.xls

Appendix F – Policy creation

Efficient spending and infrastructure improvements that are conducive to economic growth require effective policies that can deliver projects on time and on budget.

The OECD infrastructure investment: Links to Growth and the Role of Public Policies, undertakes a review of the factors that influence infrastructure investment.



Source: OECD

The motive behind public intervention and public provision of infrastructure is an effort to address the possibility of under-provision or non-provision, given any positive externalities or public good features

Another possible issue is that of a natural monopolist being able to exert substantial market power upon consumers and businesses in such as way as to restrict competition.

When government asses various investment models they must consider a wide variety of criteria. The degree of importance attached to each of these criteria will also vary depending upon political persuasion, the provision of public finances and the underlying risk associated with the project.

With any funding method it is important that a project's economic viability is tested in a transparent manner, accounting for both the direct economic impacts and the wider social and environmental implications. This helps to ensure that the potential risks are understood by all parties involved and allows for reasonable agreements and concessions to be put in place.

Initiatives that involve private contractors and companies potentially allow for further cost effectiveness given that the private sector's primary motive is profit. In theory this should mean that they will be more effective at controlling costs, whilst also easing the burden on the current level of public finances. However, one should be aware that a profit motive has to be balanced with that of delivering value for money. Just because the government does not have to incur the bulk of the costs up front does not mean that this is the most efficient form of investment in the long term as contractual agreements may equate to more than the initial investment cost.

Within the construction phase of a project it is important to monitor performance and to streamline the decision making process. It is also necessary to clearly state where responsibilities lie minimising the chance of confusion and delays.

Papers such as, Institutions, Infrastructure, and Economic Growth[45] attempt to gauge the significance to which institutions, institutional economics, and policies are conducive to growth utilizing econometric analysis.

[45] Esfahani, Hadi Salehi and Ramirez, Maria Teresa Teresa, Institutions, Infrastructure, and Economic Growth (November 1999). Available at SSRN: http://ssrn.com/abstract=193808 or doi:10.2139/ssrn.193808

- “Cross-country estimates of the model indicate that the contribution of infrastructure services to GDP is substantial and in general exceeds the cost of provision of those services.”
- “The results suggest that institutional capabilities that lend credibility and effectiveness to government policy play particularly important roles in the development process through infrastructure growth.”
- “As the model and estimation results suggest, this takes institutional and organizational reforms that are more fundamental than simply designing infrastructure projects and spending money on them.”

The paper also identifies areas in which the model and data could undergo further improvement and development. Recommendations include expanding the sectors the dataset covers, the integration of projects that are part state/private funded, and the inclusion of data that will help to measure the performance and impactts of institutional effects.

The above reiterates that the correct institutions, regulatory and financial environment is required to attract investment. ACE has engaged in such debates with papers outlining the creation of an Infrastructure bank, and utilising alternative funding mechanisms such as Infrastructure gilts.

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