Office for National Statistics

Article

Developing new measures of infrastructure investment: July 2017

The first in a series of articles on infrastructure statistics, focusing on definitional and data challenges in measuring infrastructure investment.

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Correction

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A correction has been made to the labeling of Table 3. You can see the original content in the superseded version. We apologise for any inconvenience.

Table of contents

1 . Main points

- Office for National Statistics (ONS) is developing new measures of infrastructure for the UK, starting with flows of current price investment in fixed assets.
- We focus our initial analysis on economic infrastructure (transport, energy, water, communications, waste, and flood defences); the scope of this work could be extended in future to include housing and social infrastructure.
- Our initial estimates suggest that in 2015, government investment in infrastructure was £16.2 billion, with over 80% on transport infrastructure.
- Our initial estimates suggest that in 2015, private sector investment in infrastructure was £15.4 billion, of which £12.1 billion was by the energy, and oil and gas industries.
- In 2016, the value of new infrastructure construction work undertaken by the construction industry was £19.1 billion, which accounted for 19% of its total new work.
- Future development work will explore the measurement of prices, stocks and services of infrastructure.

2 . Introduction

This is the first in a series of articles that set out how Office for National Statistics (ONS) is developing statistics on infrastructure. We are taking forward a programme of work to develop a range of new measures of infrastructure, starting with flows of current price infrastructure investment. This follows work by Grice (2016), which highlighted the potential of UK National Accounts and other data sources in measuring these assets.

Infrastructure assets are widely considered to be an important determinant of productivity and a majority of academic studies find a positive effect of infrastructure on productivity and economic growth (Romp and de Haan, 2007). Improvements in infrastructure are thought to increase productivity through reducing the costs of production, reducing barriers to trade, increasing competition through opening up markets and widening the pool of labour from which firms can choose. Conversely, the weakening of an economy's infrastructure is likely to have a negative impact on productivity: raising the costs of production, reducing the efficiency of trading relationships and limiting market access.

The quality and quantity of infrastructure assets are consequently thought to be important factors in explaining productivity levels and developments in the "stock of infrastructure assets" may play an important role in enhancing the productive and allocative efficiency of an economy over the long-term. Statistics on investment in infrastructure and the corresponding impact on stocks of these assets and the services derived from them, would therefore be valuable to inform the design of effective policy. As a result, we have identified infrastructure as one of the priorities for research to contribute to the debate on the productive potential of the economy.

This article outlines our initial research on possible approaches to measurement of infrastructure, focused on current price investment. We discuss what we can learn from current approaches to defining and measuring infrastructure and present experimental data on infrastructure investment currently available for the public and private sectors. We also highlight the main methodological issues to be addressed and outline our future plans for development.

We welcome your feedback to inform the development of these measures. Feedback should be directed to our inbox: Productivity@ons.gov.uk. This is the first in a series of articles, to be followed by further articles on prices and measuring infrastructure stocks and services in early 2018.

3 . Definitions of infrastructure

There is currently no definition of infrastructure in either the UK's National Accounts, or the international guidance embodied in the System of National Accounts (SNA) 2008 and the European System of Accounts (ESA) 2010.

There are some main definitions of infrastructure used by policymakers in the UK.

The HM Treasury Green Book describes infrastructure in broad terms as "the basic physical structures and assets needed for the operation of our society and economy".

The National Infrastructure Delivery Plan 2016 to 2021, published by the Infrastructure and Projects Authority, covers economic infrastructure, housing and social infrastructure. Economic infrastructure is taken to refer to transport, energy, water and waste handling assets, as well as flood defences and digital communications. However, it also recognises that infrastructure can include housing and social infrastructure such as education, health and justice. It also includes investment in science and research infrastructure – which might be seen to go beyond the definition in the Green Book.

The remit of the National Infrastructure Commission, which was established in 2016 to provide the government with impartial, expert advice on major long-term infrastructure challenges, is economic infrastructure. They refer to "the basic physical and organisational structures and facilities (for example, buildings, roads, power supplies) needed for the operation of a society or enterprise".

While these high-level definitions provide a starting point for considering what is meant by infrastructure, further work was needed to construct a detailed and transparent classification for use in measurement. To explore this, we reviewed the academic literature and the practices of National Statistical Institutes (NSIs) from around the world, to see what we could learn from existing approaches to measuring and defining infrastructure. We found that the literature presents a number of options for defining infrastructure, although some are more practical than others. Further details of the literature we reviewed can be found in the Annex.

Main findings

In early studies, infrastructure was often treated as synonymous with public capital. More recent work acknowledges the important distinction that must be made between these two concepts, since not all public capital is infrastructure (the many departmental office buildings for example) and not all infrastructure is public (the mobile phone network is owned and managed by private companies). As a result infrastructure is likely to be a subset of public capital assets and a subset of private capital assets.

One approach to measurement proposed in the literature is to set out either the characteristics or functions of infrastructure and assets that exhibit some or all of these are then included as infrastructure. Characteristics can be physical (how an asset looks or operates) or economic (how an asset behaves in an economic context, especially in relation to market structure or externalities).

Physical characteristics are rarely sufficient in this approach, since they do not allow for the inclusion of non-traditional infrastructure assets. For example, radio spectra and telegraph poles have very different physical characteristics, but both are essential in providing communications services. Economic characteristics are employed more frequently in the literature. These include:

- long-term – tend to have long useful lives and can take a long time to build
- limited divisibility – can only be increased in large increments
- location-specific – often remain in fixed geographic locations for long periods of time
- interdependent – rely on one or more other infrastructure assets or networks
- scale effects – generate benefits that are greater than those generated by the sum of their parts, subject to effective organisation
- public good characteristics – are often “non-excludable” (not possible to exclude people from using) and “non-rival” (marginal costs are zero)
- market power – can be subject to natural monopolies where there are high fixed costs and increasing returns to scale

The drawback of using economic characteristics is that they often encompass a larger set of assets than might be desired in the definition of infrastructure. Buhr (2003) suggests that many of the characteristics of infrastructure used in the literature can be applied to assets outside conventional definitions of infrastructure. For example, much production machinery also has long useful lives and limited divisibility, while scale effects can be found in many industries. Monopoly power can also be seen to exist in some non-infrastructural industries, often conferred to some degree by intellectual property protection regimes.

The functional approach considers not what the asset is but what it does. Functions can be broad in scope and includes all assets providing infrastructure services. Important functions of infrastructure include all capital assets that maintain health and personal safety of the population (for example, the water and utilities networks, and flood defences), enable people to work (for example, the transport network) or the production and sale of outputs (for example, the energy, transport and communications networks).

The functional approach is supported by the inclusion of infrastructure in a functional classification hierarchy in the European System of Accounts (ESA) 2010. There are many classification hierarchies for different purposes, such as those that categorise products, industries, or types of expenditure. One of the four functional classifications that exist in ESA 2010 is the Classification of Outlays of Producers by Purpose (COPP), which is used to classify certain expenditures of producers[1]. One of the categories denoted in COPP is “outlays on infrastructure”, which includes sub-categories relating to road construction, engineering and technological work, and information management. While this classification is not sufficiently detailed to allow a thorough examination of infrastructure, and no data are collected on this basis by Office for National Statistics (ONS), it does support the view that infrastructure should be considered as a purpose, or function, rather than according to its characteristics.

A simplification of the functional approach, often used in applied studies, is to identify broad types of infrastructure, containing groups of assets that are commonly considered to provide the functions of infrastructure. Table 1 presents the types of infrastructure most commonly used in applied studies, which provide the functions of infrastructure described previously and others, which are generally considered as infrastructural. They also coincide with the remit of the National Infrastructure Commission.

Table 1: Types of Infrastructure

Type of infrastructure	Description	Rationale
Transport	Primary focus is on road (including bridges, tunnels, and similar) and rail assets. Also considers seaports and airports.	Appears in all of the reviewed literature, and so is arguably the most widely accepted infrastructure asset.
Energy	Includes power distribution and transmission networks, especially electricity. Also includes some generation assets, such as in the oil and gas industries.	Almost as common as transport assets and is included in almost all of the reviewed literature. Some researchers exclude generation and supply from infrastructure measures.
Water	The main components are the water distribution and purification networks.	Appears alongside energy in almost all of the reviewed literature.
Communication	Includes telecommunication and digital communication assets. In this article, we focus on produced assets, but non-produced assets, such as radio spectra, could also be considered in this category.	Included in most of the reviewed literature, although is less common than transport, energy and water. This might be due to the recent rapid development of communications technologies, meaning that older studies had less cause to include them.
Waste	This group covers assets for the collection and disposal of hazardous waste, solid waste, wastewater, and sewage.	When not identified as a sub-section of water assets, waste is a relatively common inclusion.
Flood defences	Includes waterways, dams and levees.	When not identified as a sub-section of water assets, flood defences are a relatively common inclusion. This group is separately identified by the National Infrastructure Commission.

Source: Office for National Statistics

In this article we have chosen to take the simple functional approach to defining infrastructure in the first instance using the types of infrastructure in Table 1. This is in line with the National Infrastructure Commission and current policy, and we similarly refer to these six types: transport, energy, water, communications, waste and flood defences, as economic infrastructure. These are also most easily identified through our existing data. As we develop the measures further we can extend the scope to produce a range of measures, including on housing and social infrastructure, such as educational and healthcare buildings depending on user feedback [2]. We will also consider links to ONS work on other capitals such as Natural Capital and Human Capital although we do not plan to include these within the scope of our measures.

Notes for: Definitions of infrastructure

1. The other three functional classifications in ESA 2010 are: Classification of the Functions of Government (COFOG), Classification of Individual Consumption According to Purpose (COICOP) and Classification of the Purposes of Non-Profit Institutions Serving Households (COPNI). The four hierarchies collectively aim to cover all activity in an economy.

2. The potential interaction between economic infrastructure and the housing supply is recognised by the National Infrastructure Commission.

4 . Measuring investment in infrastructure - main terms and approach

This section sets out our approach to measuring infrastructure investment and our data sources. All of the data sources in this section cover economic infrastructure (transport, energy, water, communications, waste and flood defences), as described previously.

Investment, stocks and services

It is important to distinguish between investment in infrastructure and the corresponding impact on the stocks of these assets and the services derived from them (see Volume Index of Capital Services). Investment measures the inflow of expenditure into forming new infrastructure assets and expenditure to repair and maintain existing infrastructure assets. These investments accumulate over time to form a stock of assets, which encompasses all assets still in use in the economy. The existing stock is also affected by depreciation – the outflow from wear and tear or obsolescence that reduces the productive services it generates. Productive services are derived from the whole of the infrastructure stock, the existing stock as well as new investment.

This article focuses on infrastructure investment as a starting point as this is more readily available from the data. We intend to develop measures of the stock of infrastructure and the services that these assets provide into production. These will be especially important when exploring the impact of infrastructure assets on productivity. However, doing so involves a number of methodological challenges. Our plans are presented in the Future developments section.

Prices

In all cases, the data are presented in current prices, which means that there has been no adjustment for inflation. As such, year-on-year changes cannot be analysed using these data, but differences between components within a year can be analysed. We will work to develop a price index, or price indices, as part of the future development of infrastructure statistics; this is discussed in more detail in the Future developments section.

Data sources

There are several possible sources of current price investment data, which vary in their coverage and measurement basis. As ownership of infrastructure assets is thought to currently be split evenly between the public and private sectors and future planned investments are also financed by both public and private sectors, we have identified data sources covering both sectors. In this section, we will present some high-level analysis from three main data sources and discuss their strengths and limitations. These are:

- general government expenditure data from European System of Accounts: ESA Delivery Table 11 (Annual Expenditure of Government)[1], sourced mainly from administrative data from the Online System for Central Accounting and Reporting (OSCAR), the Department for Communities and Local Government (DCLG) and the devolved administrations in Scotland, Wales and Northern Ireland
- private sector survey data from the Annual Acquisitions and Disposals of Capital Assets Survey (ACAS)
- construction industry data collected by survey, covering work done for both the public and private sectors

These data sources reflect two ways of measuring infrastructure. Firstly, due to their long-lived nature and repeated use in production, infrastructure assets can be readily thought of as capital assets. As such, our first two data sources consider capital investment data, covering first general government and then the private sector. The data covering government use gross fixed capital formation (GFCF), which is a measure of the net investment (acquisitions less disposals) of fixed assets. GFCF includes all costs associated with an investment, such as costs of ownership transfer, installation costs and taxes less subsidies on products. The data from ACAS are conceptually closer to GFCF than data on construction (see more later in this section). Data from ACAS will not include costs of ownership transfer or installation costs, but will include integrated machinery products and will be valued at the price the purchaser pays.

Second, given the often physical nature of economic infrastructure assets, we present data on construction work that identifies the value of work to create new infrastructure and work to repair and maintain existing infrastructure. Infrastructure is sometimes referred to as the "built environment", supporting the view that infrastructure assets are generally built or constructed. Data on construction cover work undertaken by construction firms for public and private sector clients. Construction data are not directly comparable with GFCF, since the measurement focus is different – the construction data provide an output measure and so will not include any of the extra costs related to investment, listed previously. It will further not reflect VAT charged to the purchaser. As previously explained, the data also only covers the construction industry, so will not include construction work done by non-construction firms for their own use.

As well as differing in their measurement basis, these data sources are also not mutually exclusive. It is likely that construction output is accounted for to some extent in the government and private sector data sources we present, since construction firms carry out work for public and private sector clients, who will in turn report this expenditure as investment for their own use. Furthermore, there is likely to be some infrastructure investment activity that is not captured in our current data sources, such as that carried out by public corporations. As such, total infrastructure investment should not be taken as the sum of the estimates presented here.

Table 2 summarises the coverage and types of data that we have included. In addition to the administrative and survey data sources mentioned previously, there is also the potential to use financial data available in company accounts to identify investment in infrastructure. We are currently exploring the feasibility of using private sector financial data for future work and results are not presented here. We compare data from the Whole of Government Accounts (a consolidated set of financial statements for the whole of the UK public sector) with our results in the Comparisons with other Data Sources section.

Table 2: Data framework

	Survey data	Administrative data	Financial data
Public sector	Construction	OSCAR, Local Government Finance returns	Whole of Government Accounts
Private sector	ACAS, Construction		Company accounts

Source: Office for National Statistics

Notes for: Measuring investment in infrastructure – main terms and approach

1. Legislation requires that certain data are transmitted to Eurostat, including annual government expenditure data, which is contained in ESA delivery Table 11. ESA Table 11 is produced for central government, local government and general government.

5 . General government estimates

General government expenditure data are available in European System of Accounts (ESA) delivery Table 11, which includes annual UK government expenditure data broken down by type of spending and by function, using the Classification of Functions of Government (COFOG). COFOG is one of the four functional classifications that exists in ESA 2010 and is used to classify the activities of government. COFOG covers a wide range of activities, including some which we identify as infrastructure; we set these out in this section.

Separate data exist for central and local government in ESA Table 11, which permits a more granular view of investment at different levels of government. To identify investment rather than current spending, we use data on gross fixed capital formation, which reflects spending on capital assets in the year.

The central government data is sourced from the Online System for Central Accounting and Reporting (OSCAR), which is an administrative data source of central government spending. Future work will explore the feasibility of using OSCAR to develop a more granular view of central government investment in infrastructure. The local government data are collected from statistical returns and administrative sources. The data are collected mainly by the Department for Communities and Local Government (DCLG), or by the devolved administrations in Scotland, Wales and Northern Ireland. In contrast to central government data, where the reporting departments allocate the COFOG codes on OSCAR, Office for National Statistics (ONS) allocates the appropriate COFOG category to the local government data.

To identify how much is investment in infrastructure, rather than investment in other capital assets not included in our definition of infrastructure (such as military equipment or departmental buildings), we select certain codes in the COFOG hierarchy that correspond to our definition. The codes we identify as falling within the definition of infrastructure we have used are:

- 4.5 – Transport
- 4.6 – Communication
- 5.1 – Waste management
- 5.2 – Waste water management
- 6.3 – Water supply
- 6.4 – Street lighting

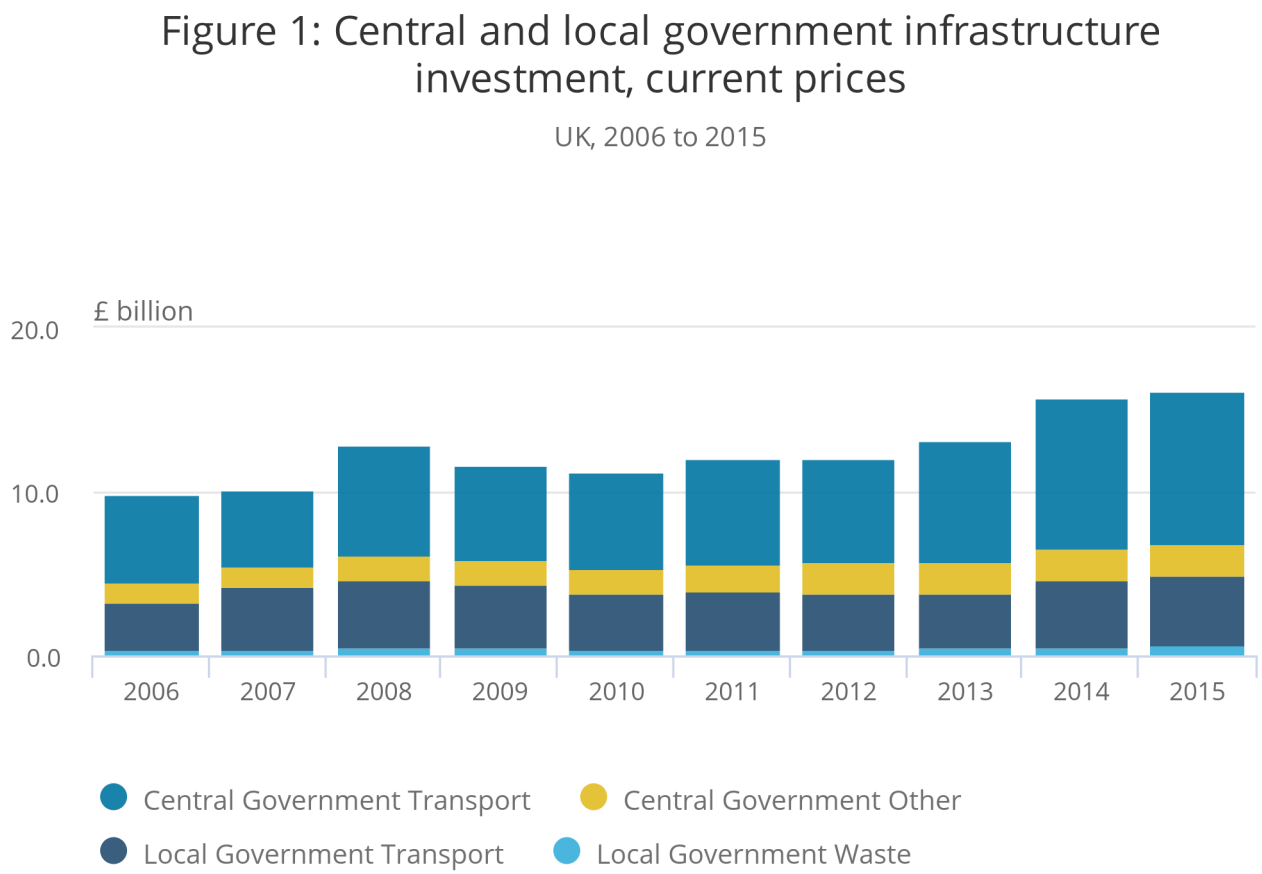
As this work develops and we look to expand and refine the definition of infrastructure we have used, to include a broader array of assets such as social infrastructure or housing, the list of COFOG codes we include could also be extended. This is similar to the approach taken by Baldwin and Dixon (2009), who use a flexible taxonomy of infrastructure assets, which encompasses a broader measure than adopted here.

In this section we present data covering the period from 2006 to 2015. We will be exploring the availability of a consistent time series for the period before 2006, specifically using available data from ESA Table 11 from 1995.

Figure 1 shows gross fixed capital formation in infrastructure assets by central and local government for the period 2006 to 2015, in current prices. General government investment in infrastructure in 2015 was £16.2 billion, compared with £9.8 billion in 2006. Figure 1 shows that about two-thirds of government investment in infrastructure in the past decade has been carried out by central government, and the other third by local government. Investment in transport assets, which is largely dominated by roads, has accounted for over 80% of total government investment in infrastructure since 2006[1]. The remaining investment is mainly in waste and water assets.

Figure 1: Central and local government infrastructure investment, current prices

UK, 2006 to 2015



Source: Office for National Statistics

Notes:

1. "Central government other" contains all selected COFOG codes apart from 4.5 – Transport, which is contained in "Central government transport". Of the COFOG codes selected, Local government investment only exists under COFOG codes 4.5 – Transport and 5.1 – Waste management, which leads to the groups in the table.

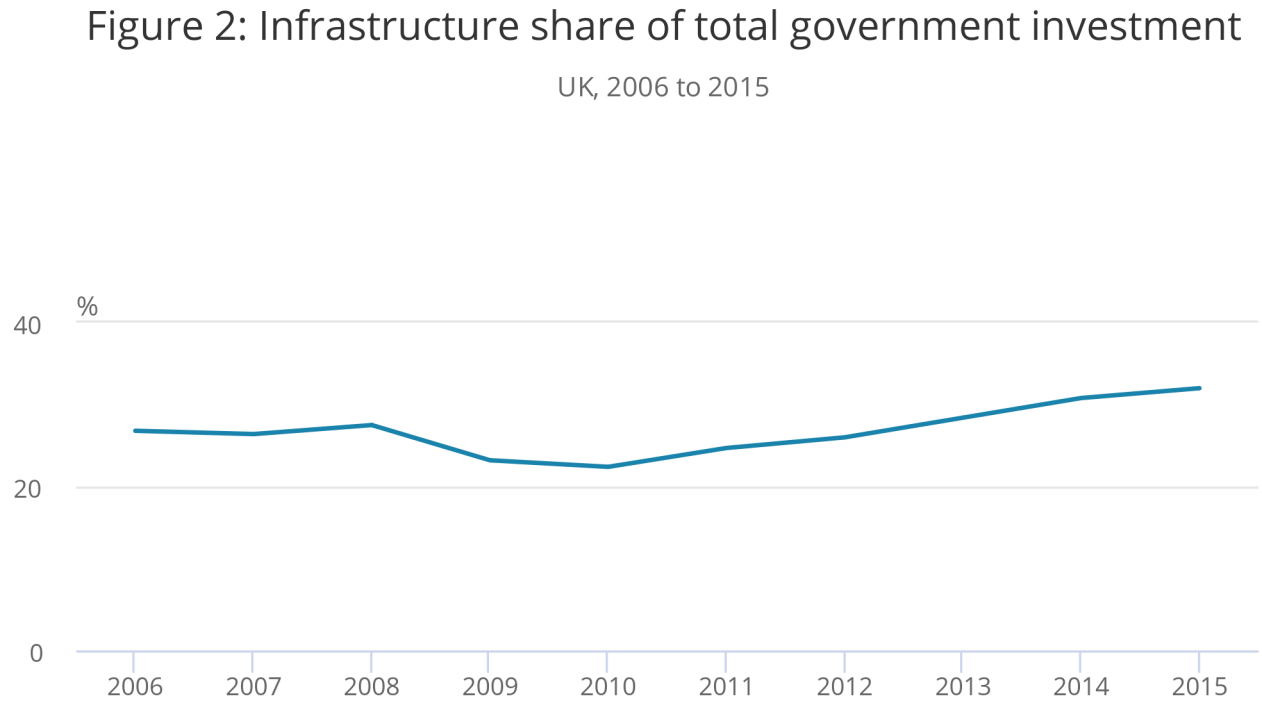
2. The data comes from ESA Table 11.

3. The data is in current prices, which means it has not been adjusted for inflation, so year-on-year changes in the levels should not be analysed.

Figure 2 shows the share of total government investment that is accounted for by investment in infrastructure assets. We present this as a way of examining changes in investment over time, as the investment data is in current prices, which means it has not been adjusted for inflation and so the levels of this data should not be compared on a year-to-year basis. Government investment in infrastructure assets has grown as a share of total government investment since the economic downturn of 2009 to 2010. Infrastructure's share fell from around 27% between 2006 and 2008, to about 23% in 2009 and 2010, before growing steadily between 2010 and 2015. Infrastructure accounted for 32% of the total in 2015, the highest share over this period. More broadly, government investment in infrastructure was 0.9% of current price gross domestic product (GDP) in 2015.

Figure 2: Infrastructure share of total government investment

UK, 2006 to 2015



Source: Office for National Statistics

Notes for: General government estimates

1. Central Government transport includes spending by Network Rail of approximately £6.5 billion in 2015.

6 . Private sector estimates

ONS conduct a number of surveys of private sector companies that ask about investment in capital assets, however, many of these are not sufficiently granular to identify infrastructure investment [1]. The Annual Acquisitions and Disposals of Capital Assets Survey (ACAS) is one exception. This survey was revised in 2014 to include new questions that allow the identification of infrastructure investment for the first time. ACAS has a relatively small sample of 2,500 firms, but it does include a census of large firms (those with employment over 1,000), which may be more likely to conduct infrastructure investment activities than smaller firms.

The questions on ACAS that allow the identification of infrastructure investment ask firms to report their expenditure on:

- civil engineering work – road and rail construction, runways, bridges, construction of power, communication, gas, pipelines and other utility projects, constructions for sport and recreation

- specialised construction work – the construction of oil wells, wind farms, turbines, tunnels, flood barriers, drains

Table 3 shows expenditure by private sector firms on “civil engineering work” and “specialised construction work” [2] in the UK, in current prices, for 2014 and 2015. The data includes outsourced work and is weighted to be representative of the whole economy. Total private sector investment in infrastructure using this measure was £18.4 billion in 2014 and £15.4 billion in 2015.

Table 3 also breaks the total amount of spending into four categories, based on the industry group reporting the expenditure: oil and gas, energy, water and waste, and other. The industries included in these groups are given in the notes below Table 3. The results suggest that close to half of total private sector investment in infrastructure is carried out by the oil and gas industry, while the energy industry also carries out a large fraction of the total.

Table 3: Private sector infrastructure investment by industry, current prices

UK, 2014 and 2015

£ Million

	2014	2015
Oil and Gas	9,724	6,734
Energy	4,679	5,354
Water and Waste	1,925	2,097
Other	2,078	1,227
Total	18,406	15,412

Source: Office for National Statistics

Notes:

1. Oil and Gas refers to industry 06; Energy refers to industry 35; Water and Waste refers to industries 36-39; Other refers to all other industries.

2. Unweighted sample sizes: 2014 – Oil & Gas = 18, Energy = 14, Water & Waste = 21, Other = 129; 2015 – Oil & Gas = 19, Energy = 12, Water & Waste = 24, Other = 119.

3. Data are in current prices so have not been adjusted for inflation. Year on year changes in the levels should not be analysed.

Business investment is a measure of net investment by the private sector and does not include investment by government or investment in dwellings. Our estimate of private sector investment in infrastructure was 9% of total business investment in 2015, which was £180 billion over the same period.

Notes for: Private sector estimates

1. The Quarterly Acquisitions and disposals of Capital Assets Survey (QCAS), previously the Quarterly Survey of Capital Expenditure (CapEx), and the Annual Business Survey (ABS) also ask about investment in capital items, but do not ask questions of sufficient detail to identify infrastructure investment.

2. Expenditure for both of these questions have been combined in Table 1, as splitting the data further would lead the number of observations in each group to be too small for publication due to disclosure rules.

7 . Construction industry activity

ONS conduct a targeted monthly survey of the construction industry, sampling approximately 8,000 construction firms per month. As part of the survey, construction firms are asked to report the value of new infrastructure construction work and the value of repair and maintenance work (R&M) to existing infrastructure assets that they carried out during the month.

The Construction Survey defines infrastructure as: water, sewerage, electricity, gas, communications, air transport, railways, harbours and roads, which is consistent with our definition of infrastructure. The survey data reflects the value of total construction work by construction firms, which includes work completed on behalf of both public and private sector clients. However, it will not include any construction work carried out by non-construction firms, such as firms in the energy or mining industries, or government departments for their own use – as such, it will not include work carried out by Network Rail, but will include work carried out by construction firms on behalf of Network Rail. Construction output data will not include transfer costs, installation costs, or taxes less subsidies on the relevant construction products, which are included in the value of the investment.

Some infrastructure assets will also be created through a combination of outsourced construction activity and in-house development of specialist equipment or software. For example, a mobile phone mast may well be erected by a construction company, but the specialist software that allows it to emit and receive radio waves would likely be developed and installed by the telecommunications firm and thus not identified in construction surveys. As such, construction data is likely to be a lower bound for total infrastructure investment.

In this section ONS present data for the period from 2010 to 2016, which is the period over which ONS has collected these data. Future work will look to develop a longer consistent time series, potentially going back to 1980.

Table 4 shows the total value of infrastructure construction work by type [1], in current prices, for 2010 to 2016. Electricity accounted for the largest share of the total in 2016, of over 40%, while roads (25% in 2016) and railways (12% in 2016) also make considerable contributions. It is likely that for types of work with smaller values, such as water and communications (included in other), more construction is carried out by non-construction firms.

Table 4 also shows the breakdown of total new infrastructure work that is carried out on behalf of public and private sector clients. In 2016, just under two-thirds of new infrastructure construction work was funded by the private sector, the highest share since 2012.

The value of new infrastructure construction work for the private sector in 2015 was £12.6 billion, which is relatively close to the £15.4 billion of private sector infrastructure investment shown in Table 3 for 2015; this suggests that a large proportion of infrastructure investment by the private sector is carried out by construction firms. This is less the case when considering the public sector, as the value of infrastructure investment by government shown in Figure 1 for 2015 far exceeds the value of new infrastructure construction work for the public sector shown in Table 4. This suggests that public sector bodies that invest in infrastructure are likely to have considerable capacity to carry out those investments themselves and less need to contract work to the construction industry.

Table 4: Infrastructure Construction (New Work) by type and sector of client, current prices

Great Britain, 2010 to 2016

£ million

	2010	2011	2012	2013	2014	2015	2016
Water	2,252	2,450	2,140	1,590	867	869	867
Sewerage	965	916	651	510	409	976	1,811
Electricity	1,419	2,140	2,592	3,582	5,464	8,359	8,189
Roads	4,044	3,764	2,285	2,600	3,137	5,684	4,747
Railways	2,837	3,835	4,660	4,759	3,491	2,878	2,368
Harbours	516	556	508	645	788	994	651
Other	1,508	1,658	1,589	1,651	1,228	729	450
Total	13,540	15,320	14,425	15,334	15,384	20,488	19,083
of which public	5,205	5,351	4,646	5,567	5,766	7,888	6,503
of which private	8,335	9,969	9,779	9,767	9,617	12,599	12,580

Source: Office for National Statistics

Notes:

1. Other includes Air Transport, Gas, and Communications.

2. Data are in current prices so have not been adjusted for inflation. Year on year changes in the levels should not be compared.

Table 5 breaks down the total value of new infrastructure construction work by region. The highest share of infrastructure construction in 2016 took place in Scotland (16%), with the share for London the next largest (15%). The lowest share in 2016 was in the West Midlands (4%) and the share in the North East was next lowest (5%). The share of work in London has declined over the period in Table 5, from a peak of 27% in 2012 to a low of 12% in 2015, before recovering somewhat in 2016. The share of work in Scotland has seen the largest increase of any region over the period, rising from a low of 9% in 2011 to a peak of 20% in 2015. However, these trends are likely in part to reflect changes in the nature of infrastructure investment undertaken in different regions and the relative prices of those activities.

At present, ONS do not have data by region for the public sector (as presented in Figure 1) or for the private sector as a whole (as presented in Table 3). The regional data in Table 5 only reflects work undertaken by the construction industry and so should not be treated as representative of all infrastructure investment.

Table 5: Infrastructure Construction (New Work) by region, current prices

Great Britain, 2010 to 2016

£ million

	2010	2011	2012	2013	2014	2015	2016
North East	229	444	626	632	861	1047	931
North West	1,441	1,391	1,123	1,547	1,757	1,934	2,073
Yorkshire and the Humber	1,214	991	1,260	1,533	1,337	1,288	1,019
East Midlands	764	876	953	886	784	1,331	1,384
West Midlands	807	857	771	782	685	785	782
East of England	1,180	1,397	1,378	1,547	1,668	2,158	2,045
London	2,975	3,950	3,888	3,379	2,347	2,545	2,839
South East	1,992	2,556	1,918	1,854	1,812	2,613	2,409
South West	633	838	752	852	994	1,360	1,056
Wales	693	707	500	556	608	1,345	1,473
Scotland	1,610	1,314	1,256	1,767	2,532	4,084	3,072

Source: Office for National Statistics

Notes:

1. Data are in current prices so have not been adjusted for inflation. Year on year changes in the levels should not be analysed.

Table 6 compares new infrastructure construction work with work to repair and maintain existing infrastructure assets (R&M). Infrastructure R&M work was about half the value of new infrastructure work between 2010 and 2014, but has fallen to nearer 40% in 2015 and 2016. Work on infrastructure represented a higher share of total new work than total R&M over the period 2010 to 2016. New work on infrastructure accounted for 19% of total new work in 2016 while R&M work on infrastructure accounted for 16% of total R&M work.

Table 6: Infrastructure Construction (New Work and Repair and Maintenance), current prices

Great Britain, 2010 to 2016

	2010	2011	2012	2013	2014	2015	2016
Infrastructure New Work (£m)	13,540	15,320	14,425	15,334	15,384	20,488	19,083
Infrastructure Share of Total New Work (%)	18%	20%	20%	20%	18%	22%	19%
Infrastructure Repair and Maintenance Work (£m)	6,841	7,762	7,672	8,086	8,809	8,496	7,997
Infrastructure Share of Total Repair and Maintenance Work (%)	16%	18%	17%	17%	17%	17%	16%

Source: Office for National Statistics

Notes:

1. Data are in current prices so have not been adjusted for inflation. Year on year changes in the levels should not be analysed.

Notes for: Construction industry activity

1. The breakdowns in Tables 4 and 5 are partly derived using data from Barbour ABI. Full details can be found in the Construction Output statistics QMI.

8 . Comparison with other data sources

The Whole of Government Accounts (WGA) is a consolidated set of financial statements for the whole of the UK public sector and provides some useful comparison for our public sector investment data. For the financial year ending 2015, additions to the infrastructure stock were valued at £11.2 billion in the WGA, which is approximately £5 billion less than the value of general government investment in infrastructure in our data for a comparable period (as shown in Figure 1). This can be explained by differences in scope and treatment of some assets, since public sector bodies reporting for the WGA may use a different definition of infrastructure. For instance, the WGA records nuclear decommissioning investment separately from infrastructure assets, which differs to the Classification of Functions of Government (COFOG) treatment in the Online System for Central Accounting and Reporting (OSCAR). The value of construction work for public sector clients is also broadly consistent with additions in the WGA[1].

The Infrastructure and Projects Authority's National Infrastructure and Construction Pipeline offers another useful comparison with our data. The Pipeline records planned spending, including information about future infrastructure and construction projects that have been committed to by the private and public sectors. The Pipeline also includes one year of outturn data, which is the best point of comparison. The comparability of the data varies by sector, with transport and energy broadly consistent, while investment in utilities is less consistent. However, since the Pipeline uses the value of the project as a whole, these estimates are likely to be an upper bound on actual investment, since projects require some expenditure on administration and planning.

Notes for: Comparison with other data sources

1. Network Rail carry out some of their own construction work, so comparison of WGA with Construction data requires an adjustment to account for this. After making this adjustment, the two data sources are broadly consistent.

9 . Future developments

This is the first in a series of articles that will explore the development of infrastructure statistics.

We plan to develop and expand our measures of investment. Future work will include incorporating more detailed analysis of government and construction data at a more granular level and over a longer time series. We will also investigate the potential of using company accounts data for private sector data on infrastructure investment.

Beyond infrastructure investment, we intend to develop measures of the stock of infrastructure assets and the services these assets provide into production. These will be especially important when exploring the impact of infrastructure on productivity. An important part of that work is the need for a price index, or multiple price indices, for infrastructure assets, so as to allow analysis of investment, stocks and services over time. We will also look to address some of the methodological challenges in developing measures of stocks and services, such as specific service lives for the relevant assets.

While the need for a price index, or multiple price indices, is clear, data on the prices of infrastructure assets is lacking. In the case of public infrastructure, assets prices often lead to conceptual problems, since these assets are not traded in the market and so do not command prices in the conventional sense. Similarly, many large-scale projects are only completed once in a generation and so price changes over time, especially in years between the completion of these projects, are difficult to record. These and more problems are discussed in the OECD Construction Prices Manual, which we will refer to as part of this work. We welcome your suggestions on how to approach these challenges, including existing data or approaches that could be used.

Given these challenges, we will develop this work in a series of articles during 2017 to 2018. The first will consider prices and from there we will move onto stocks and services. Emerging strands of work for this include updating and extending methods used in Grice (2016). Another strand of work on stocks is to look at the potential of a full taxonomy of infrastructure assets for use in the National Accounts Capital Stocks system. We will also explore data on public sector infrastructure stocks from a range of sources, including the Whole of Government Accounts and data held by regulators such as OFWAT and OFCOM. In the longer-term we will look to develop a methodology to include infrastructure assets in a growth accounting framework, in order to estimate productive services from infrastructure stocks.

Your views

We are keen for your involvement in the development of these new statistics. We would welcome any feedback you may have and would be particularly interested in knowing how you make use of these data to inform your work. Feedback should be directed to our inbox: Productivity@ons.gov.uk.

10 . Annex: Literature review summary

Annex: Literature review summary

Paper	Description
American Society of Civil Engineers (ASCE) (2013) 'Infrastructure Report Card'	A report on the performance of US infrastructure. Identifies 16 types of infrastructure: Energy, Schools, Public Parks and Recreation, Transit, Roads, Rail, Ports, Inland Waterways, Bridges, Aviation, Wastewater, Solid Waste, Levees, Hazardous Waste, Drinking Water, Dams.
Aschauer (1989) 'Is Public Expenditure Productive?'	An early study of the impact of infrastructure on productivity and economic growth using data for the US. Used public sector expenditure as a proxy for infrastructure spending.
Baldwin and Dixon, Stats Canada (2008) 'Infrastructure Capital: What Is It? Where Is It? How Much of It Is There?'	Measurement of Canadian infrastructure stocks, using a COFOG- based approach. Sets out the characteristics of infrastructure and suggests 10 groups of assets that meet these: Communications, Transportation, Energy distribution, Electricity, Waste, Water and sewage, Recreation, Culture and education, Health and social protection, Defence and public safety.
Beca, Covec, for National Infrastructure Unit, The Treasury (NZ) (2013) 'Infrastructure Performance Indicator Framework Development'	Development of a performance indicator framework for assessing infrastructure in New Zealand. Covers four types of infrastructure: Transport, Telecommunications, Energy, Water.
Buhr (2003) 'What is infrastructure?'	Theoretical paper on the definition of infrastructure. Rejects characteristics in favour of functions. Defines infrastructure as: "Infrastructure of an area is the sum of all relevant economic data such as rules, stocks and measures with the function of mobilising the economic potentialities of economic agents. Material infrastructure refers to the capital stocks that serve the function of mobilising the economic potentialities of economic agents."
Fourie (2006) 'Economic Infrastructure: A Review of Definitions, Theory and Empirics'	Review of infrastructure studies, especially relating to the definition of infrastructure. Suggests assets for inclusion as economic infrastructure: roads, highways, railroads, airports, sea ports, electricity, telecommunications, water supply and sanitation and social infrastructure: schools, libraries, universities, clinics, hospitals, courts, museums, theatres, playgrounds, parks, fountains and statues.
Grice (2016) National accounting for infrastructure	Explores the potential of UK National Accounts and other data sources in measuring. Finds that infrastructure assets are owned approximately evenly by the private and public sectors in recent years.
HM Treasury (2015) 'Valuing infrastructure spend: Supplementary guidance to the Green Book'	Guidance by HM Treasury on valuing infrastructure spend in the UK, primarily for cost-benefit analysis purposes. Suggested infrastructure assets include economic infrastructure: transport, waste management, energy, communications, water and sewerage, flood and coastal erosion management and social infrastructure: schools, prisons, courts, hospitals and regeneration projects.
McNeil, Li and Oswald (2010) 'Infrastructure Index'	Creation of a performance index of US infrastructure. Focus on four types of infrastructure: Transportation, Broadband, Water, Energy.
National Infrastructure Commission (2017) 'National Infrastructure Assessment'	Assessment of UK infrastructure, focus ed on performance indicators. Remit covers economic infrastructure: Energy, Transport, Digital communications, Solid waste, Flood defences, and Water, social infrastructure and housing.
Romp and de Haan (2007) 'Public Capital and Economic Growth: A Critical Survey'	Review of the evidence of the impact of infrastructure on productivity and economic growth. Finds a majority of studies report a positive impact of infrastructure.

Torrisi (2009) 'Public infrastructure: definition, classification and measurement issues'	Theoretical paper on the definition and classification of infrastructure. Reviews various classifications of infrastructure. Defines infrastructure as: "Material infrastructures can be defined as goods and services able to satisfy those wants of economic agents originating from physical and social requirements of human beings."

Source: Office for National Statistics

11 . Links to related statistics

5 July 2017: UK productivity introduction: Jan to Mar 2017 draws together the headlines of the productivity releases into a single release, providing additional analysis of our productivity statistics.

5 July 2017: Labour productivity: Jan to Mar 2017 contains the latest estimates of labour productivity for the whole economy and a range of industries, together with estimates of unit labour costs.

5 July 2017: Introducing industry-by-region labour metrics and productivity presents new, experimental industry-by-region productivity metrics. This includes measures of hours worked, jobs, and accompanying productivity measures for the SIC letter industries in the NUTS1 regions.

5 July 2017: Introducing division level labour productivity estimates provides an overview of new and experimental estimates of labour productivity at the 2-digit SIC industry level for the UK and provides some initial analysis demonstrating trends in the data.

5 July 2017: Who are the "laggards"? Understanding firms in the bottom 10% of the labour productivity distribution in Great Britain examines the characteristics of businesses in the bottom 10% of the labour productivity distribution in terms of their size, age, industry and location, between 2003 and 2015.

5 July 2017: Developing improved estimates of Quality Adjusted Labour Inputs using the Annual Survey of Hours and Earnings: A progress article describes work to improve the precision of income weights used in quality adjustment and to develop finer industry granularity of quality adjusted labour for multi-factor productivity.

5 July 2017: Quarterly public service productivity (experimental statistics): Jan to Mar 2017 presents experimental estimates for quarterly UK total public service productivity, inputs and output to provide a short-term, timely indicator of the future path of annual public service productivity estimates.

5 April 2017: International comparisons of UK productivity (ICP), final estimates: 2015 presents an international comparison of labour productivity across the G7 nations, in terms of growth in GDP per hour and GDP per worker.

5 April 2017: Multi-factor productivity estimates: Experimental estimates to 2015 decomposes output growth into the contributions that can be accounted for by labour and capital inputs. The contribution of labour is further decomposed into quantity (hours worked) and quality dimensions.

5 April 2017: Labour productivity measures from the Annual Business Survey, 2006 to 2015 presents an analysis of detailed productivity trends and distributions among businesses in the UK from 2006 to 2015, using firm-level data from the Annual Business Survey (ABS).

5 April 2017: Introducing quarterly regional labour input metrics provides a first look at the new experimental quarterly regional labour input metrics. Hours and jobs for the NUTS1 regions.

5 April 2017: Exploring labour productivity in rural and urban areas in Great Britain investigates differences in rural and urban labour productivity in Great Britain using firm-level microdata analysis of the business economy.

6 January 2017: Regional and sub-regional productivity in the UK: Jan 2017 provides statistics for several measures of labour productivity. Statistics are provided for the NUTS1, NUTS2 and NUTS3 subregions of the UK, and for selected UK city regions.

6 January 2017: Regional firm-level productivity analysis for the non-financial business economy: Jan 2017 provides experimental analysis on the sources of regional differences in labour productivity in the non-financial business economy in Great Britain.

6 January 2017: Volume index of UK capital services (experimental): estimates to 2015 provide estimates of the contribution of the capital stock to production in the economy, split by asset and industry.

6 January 2017: Public service productivity estimates: total public service, UK: 2014 presents updated measures of output, inputs and productivity for public services in the UK between 1997 and 2013, in addition to new estimates for 2014. Includes service area breakdown, as well as impact of quality adjustment and latest revisions.

6 January 2017: Public service productivity estimates: healthcare, 2014 presents updated estimates of output, inputs and productivity for public service healthcare in the UK between 1995 and 2013, and new estimates for 2014.

6 October 2016: Quality adjusted labour input: UK estimates to 2015 includes estimates of changes in the number of hours supplied in the UK economy adjusted for changes in the quality of the labour supply.