The need for indigenous aggregates production in England

Open Report OR/08/026

BRITISH GEOLOGICAL SURVEY

OPEN REPORT OR/08/026

The need for indigenous aggregates production in England

T J Brown, F McEvoy and J Mankelow (BGS) with
J Ward, S Bloomfield, T Goussarova, N Shah and L Souron (cebr)

Keywords

England, aggregates, economy, construction.

Front cover

Dowlow Quarry, Derbyshire
C Mitchell, BGS © NERC

Bibliographical reference

BROWN, TJ, MCEVOY, F AND MANKELOW, J (BGS) WITH WARD, J, BLOOMFIELD, S, GOUSSAROVA, T, SHAH, N AND SOURON, L (CEBR). 2008. The need for indigenous aggregates production in England. *British Geological Survey Open Report*, OR/08/026. 74pp.

Copyright in materials derived from the British Geological Survey's work is owned by the Natural Environment Research Council (NERC) and/or the authority that commissioned the work. You may not copy or adapt this publication without first obtaining permission. Contact the BGS Intellectual Property Rights Section, British Geological Survey, Keyworth, e-mail ipr@bgs.ac.uk. You may quote extracts of a reasonable length without prior permission, provided a full acknowledgement is given of the source of the extract.

© NERC 2008. All rights reserved

Keyworth, Nottingham British Geological Survey 2008

BRITISH GEOLOGICAL SURVEY

The full range of our publications is available from BGS shops at Nottingham, Edinburgh, London and Cardiff (Welsh publications only) see contact details below or shop online at www.geologyshop.com

The London Information Office also maintains a reference collection of BGS publications, including maps, for consultation.

We publish an annual catalogue of our maps and other publications; this catalogue is available online or from any of the BGS shops.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as basic research projects. It also undertakes programmes of technical aid in geology in developing countries.

The British Geological Survey is a component body of the Natural Environment Research Council.

British Geological Survey offices

BGS Central Enquiries Desk

Tel 0115 936 3143 Fax 0115 936 3276
email enquiries@bgs.ac.uk

Kingsley Dunham Centre, Keyworth, Nottingham NG12 5GG

Tel 0115 936 3241 Fax 0115 936 3488
email sales@bgs.ac.uk

Murchison House, West Mains Road, Edinburgh EH9 3LA

Tel 0131 667 1000 Fax 0131 668 2683
email scotsales@bgs.ac.uk

London Information Office at the Natural History Museum (Earth Galleries), Exhibition Road, South Kensington, London SW7 2DE

Tel 020 7589 4090 Fax 020 7584 8270
Tel 020 7942 5344/45 email bgslondon@bgs.ac.uk

Columbus House, Greenmeadow Springs, Tongwynlais, Cardiff CF15 7NE

Tel 029 2052 1962 Fax 029 2052 1963

Forde House, Park Five Business Centre, Harrier Way, Sowton EX2 7HU

Tel 01392 445271 Fax 01392 445371

Maclean Building, Crowmarsh Gifford, Wallingford OX10 8BB

Tel 01491 838800 Fax 01491 692345

Geological Survey of Northern Ireland, Colby House, Stranmillis Court, Belfast BT9 5BF

Tel 028 9038 8462 Fax 028 9038 8461

www.bgs.ac.uk/gsni/

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU

Tel 01793 411500 Fax 01793 411501
www.nerc.ac.uk

Website www.bgs.ac.uk
Shop online at www.geologyshop.com

Acknowledgements

The authors would like to acknowledge the assistance of the many individuals and organisations that have provided images and construction details for this report, in particular Action Images Ltd (Wembley National Stadium), Midland Expressway Ltd (M6 Toll) BAA Aviation Photo Library (Heathrow Terminal 5), Leicestershire County Council and Wilmott Dixon Ltd (the two high schools), London & Continental Railways (Channel Tunnel Rail Link), Derby Hospitals NHS Foundation Trust, Skanska Integrated Projects (Derby Hospital), Tarmac Ltd, Birse Group (Blackpool Coastal Defence Scheme) and London 2012 Olympic Delivery Authority. Dr B Marker, Mr N Jackson, Mr L Hicks and Mr D Highley provided useful comments on the draft.

Whilst due consideration has been given to comments received from all consultees, this report describes the views of the authors alone. References within this publication to any methodology, process, service, manufacturer or company do not constitute its endorsement or recommendation by MIRO or DEFRA. This publication is intended to inform the land-use planning debate. It is not a statement of planning policy or guidance; nor does it imply Government approval. Whilst every effort has been made to ensure the accuracy of the material in this report, the authors, British Geological Survey and cebr will not be liable for any loss or damages incurred through the use of this report.

Contents

FIGURES

CASE STUDIES

TABLES

Summary

This report is one of two outputs from a project entitled ‘The need for non-energy indigenous mineral production in England’ which received funding from the Sustainable Land-Won and Marine Dredged Aggregate Minerals Programme of the Aggregates Levy Sustainability Fund (ASLF) managed by the Mineral Industry Research Organisation. A separate report has also been prepared relating to ‘The need for indigenous fluorspar production in England’.

This study is one of five projects undertaken in 2007 to examine many different aspects of the current system for the supply of aggregates in England.

A modern developed society creates a demand for minerals and the ‘need’ is actually to meet this demand in the interests of the economy. The aim of this project was to analyse this ‘need’ for non-energy indigenous mineral production in England, in particular aggregates and fluorspar.

This report specifically relates to the consumption of aggregates. It describes the uses of aggregates and explains why they are considered to be essential for the development of a modern economy. Many high profile construction and regeneration projects require large quantities of aggregates, such as the Olympic Park, the new Wembley stadium and Terminal 5 at London Heathrow Airport. However, there are also thousand of smaller structures built each year that require aggregates, such as new homes, schools and hospitals. This report contains nine case studies outlining some examples of how aggregates are used.

In addition to providing the materials needed to build the infrastructure that the country depends upon, the industry also brings significant benefits to the English economy. The gross value added of the English primary aggregates industry is over £1 billion per year. This consists of both the direct contribution of the industry and indirect benefits derived from the industry purchasing goods from its suppliers and employees of the industry demanding goods and services from other parts of the economy. In addition, downstream industries, such as the manufacturers of ready mixed concrete, coated roadstone, mortar and concrete products, contribute more than another £1 billion to the English economy every year. However, the largest benefit derived from the aggregates industry is in providing raw materials to the construction industry which has a gross value added contribution of more than £50 billion per year.

By comparison the estimated environmental ‘cost’ of the industry is less than £450 million per year. This includes both the ‘cost’ of amenity reduction due to impacts such as noise, air pollution and traffic congestion, and also a ‘price’ for carbon dioxide emissions.

Of the 200 to 220 million tonnes of aggregates consumed in England each year, only four per cent is imported from areas outside of England (including other parts of the UK). Significantly increasing the proportion that is imported would cause a noticeable increase in the price of aggregates, with consequential impacts on the construction industry. It would also require substantial investment in English ports to increase capacity from the current 95.7 million tonnes per year of dry bulk cargoes handled. It is by no means certain that enough suitable locations could be found to build such a large number of additional facilities.

The growth of a modern economy is likely to be directly linked to the quality of its infrastructure. The construction industry is an essential component of this infrastructure provision and aggregates are a vital raw material for this industry. Therefore an adequate and reliable supply of aggregates is essential. It is impossible to import all of England’s requirements for this high volume, bulk material and therefore the need for indigenous supplies of aggregates is of crucial importance.

1 Introduction

Aggregates are the mostly widely used construction materials in the UK. This report outlines what exactly these materials are, where they are used and why they are considered to be essential for constructing and maintaining the physical framework of our society. It also sets out the benefits which aggregates bring to the English economy and considers the environmental effects of having an indigenous aggregates industry.

In England approximately 216.7 million tonnes of aggregates were consumed in 2005 (Figure 1). In volume terms this would be enough to fill the bowl of Wembley Stadium up to the roof more than 100 times.

Of the total consumption, 96 per cent was produced within England (including recycled and secondary materials) and only four per cent was imported from other parts of the UK or overseas. But is this high level of indigenous production really necessary? With such high pressure on land use in England, could imports be higher?

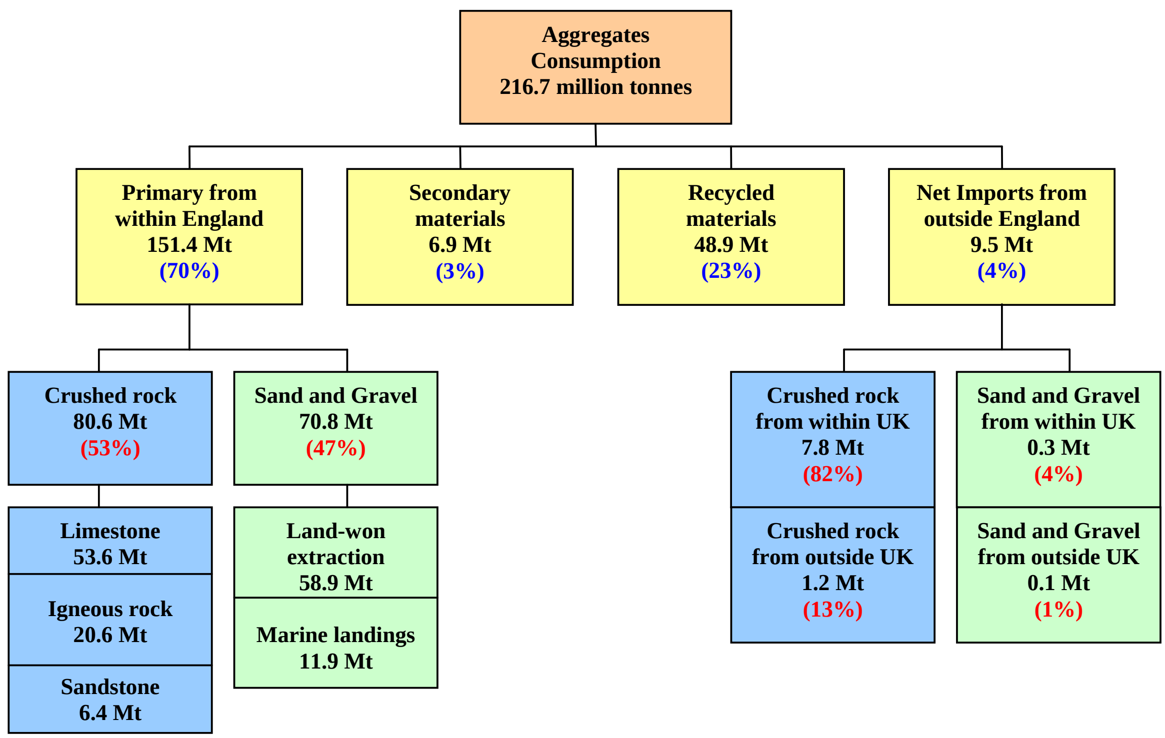


Figure 1 Breakdown of consumption of aggregates in England, 2005

Sources: Mineral Extraction in Great Britain 2005 (Office for National Statistics, 2006a), Collation of the results of the 2005 Aggregates Minerals Survey for England and Wales (British Geological Survey, 2007a) and Survey of arisings and use of alternatives to primary aggregates in England 2005 (Capital Symonds, 2006)

Note: Data for 2005 has been used throughout this report because this is the year for which most complete information is available.

To put the tonnage figures for aggregates into context, Table 1 compares the 'material flow' of primary aggregates with that for other materials such as fossil fuels. It can be seen that of all the materials extracted in the UK, 41 per cent are aggregates and this is more than the quantity of fossil fuels extracted. Once imports and exports have been taken into account the domestic material consumption of aggregates (excluding secondary and recycled materials) is only slightly less than that for fossil fuels.

The figures for timber production are included in 'biomass', together with agricultural products, animal grazing and fish. The table shows that this category is approximately half the size of the other two.

Figures for steel are not included in this table because it is not 'extracted' in the UK, although the imported iron ore required to produce steel in the UK is included under imports of 'minerals'. Steel production amounted to just over 13 million tonnes in 2005 with imports of less than 1 million tonnes and exports of 2.2 million tonnes (BGS, 2007b).

	Domestic Extraction		**Imports**	**Exports**	**Domestic Material Consumption (f)**	
	Million tonnes	**% of UK total**	**Million tonnes**	**Million tonnes**	**Million tonnes**	**% of UK total**
UK total						
All materials	583		280	177	686	
Of which:						
Fossil fuels (a)	193	33%	137	88	241	35%
Biomass (b)	100	17%	50	19	131	19%
Minerals (c)	290	50%	58	48	300	44%
Of which:						
Aggregates (d)	241	41%	2	13	230	33%
England only						
Aggregates (d) (e)	151		10	1	161	

Notes:
(a) Fossil fuels include coal, natural gas and crude oil (energy minerals)
(b) Biomass includes agricultural harvest, timber, animal grazing and fish
(c) Minerals includes metal ores, clay, industrial minerals and aggregates (non-energy minerals)
(d) Aggregates excludes material for industrial uses and building stone, also excludes secondary and recycled aggregates
(e) Import and export figures for England include material moved within the UK
(f) Domestic Material Consumption (DMC) = Extraction + Imports – Exports (although it may not sum exactly due to rounding)

Table 1 Physical flows of material in the UK, 2005

Sources: Environmental Accounts (ONS, 2007b), Mineral Extraction in Great Britain 2005 (ONS, 2006a), United Kingdom Minerals Yearbook 2006 (BGS, 2007b) and BGS calculations

The consumption of primary aggregates in the whole of the UK is almost as large as the consumption of fossil fuels. Seventy per cent of the aggregates consumed in the UK are utilised in England.

2 Aggregates in Daily Life

2.1 AGGREGATES ARE ALL AROUND US

Aggregates are used to build and maintain our houses, offices, roads, schools and hospitals. They provide a firm foundation for our railways, are used to construct factories, warehouses and shops and can protect us against flooding. On average every person in England creates the need for approximately 4 tonnes of aggregates each year – just by living their normal daily life.

They are essential materials for the construction industry, an important sector of the economy. Without them the many infrastructure projects, that bring huge benefits to the country, could not be built. The Channel Tunnel Rail Link, Heathrow Terminal 5 and Wembley Stadium are just three examples but there are many others as shown in the case study panels throughout this report. In addition to the many large scale projects that capture the public's attention, there are literally thousands of smaller structures built every year which also require aggregates, such as homes or schools.

Adequate supplies of aggregates are also essential to the delivery of the Government's future objectives of affordable housing, Sustainable Communities and major, high profile regeneration and construction projects, such as the Thames Gateway, the 2012 Olympics and Crossrail. Significant quantities will also be required for climate change adaptation, e.g. for coastal and inland flood defences, and mitigation, e.g. new nuclear power stations or renewable energy schemes such as the proposed Severn Barrage.

The largest roof covered seating capacity in the world

Wembley National Stadium

90 Thousand Spectators

£798 Million Investment

90,000 cubic metres of concrete using

180,000 tonnes of aggregates

Additional aggregates were also used in the surrounding landscaping, pavements and in the form of sand under the pitch.

Case Study 1 Wembley National Stadium

Photos: © Action Images (used with permission)
Source: Wembley National Stadium Ltd www.wembleystadium.com/buildingwembley/statsandfacts/

2.2 DEFINITIONS FOR AGGREGATES

Aggregates come in many different forms, each with its own characteristics and properties, and these determine their many different uses. The term 'aggregates' refers to any granular material usually formed from a natural rock substance. They are further defined either:

- By their source: primary, secondary or recycled
- By their geology: e.g. limestone, sandstone, granite or sand and gravel
- By their size distribution: coarse or fine
- By their end use: e.g. concrete aggregates, roadstone or mortar sand

Primary aggregates

These are materials extracted directly from the ground in quarries. They can be either sand and gravel, or 'hard' rock.

Hard rock deposits are quarried from a fresh face and broken by mechanical means into aggregates. Geologically they can be igneous rocks such as granite or basalt; sedimentary rocks such as limestone or sandstone; or metamorphic rocks such as quartzite. As aggregates, they are often referred to as 'crushed rock' or by their individual geological names. Explosives will usually need to be used to break the rock face into pieces and often the rock will pass through several stages of crushing and screening to create the final product.

Sand and gravel can be of any geological origin, but it has already been broken into pieces by the natural processes of weathering, transported by water or ice, and then deposited in a loose form. Gravel can still be in large pieces, which will need crushing, and usually all the material will need to be washed to remove fine clay particles.

Marine aggregates are sand and gravel dredged from the sea floor in permitted areas of the UK continental shelf. Further processing is again used to crush, screen and wash the material to provide the required products.

Secondary aggregates

In many parts of the aggregates industry this term is used interchangeably with 'recycled' aggregates. However, secondary aggregates can be more correctly defined as aggregates produced as a by-product of other mining or quarrying activities such as china clay waste, slate waste and colliery spoil, or as a by-product of other industrial processes, e.g. blast furnace slag, incinerator ash, or the ash from coal-fired power stations.

Recycled aggregates

Recycled aggregates are generally materials produced by the recycling of construction and demolition waste. They can be crushed concrete, bricks or glass, asphalt planings (i.e. the surface layers of roads removed during roadworks) or spent rail ballast. Processing includes crushing and screening, as with primary aggregates, but also the removal of metal, plastic or wood waste. In some locations top soil is produced as a by-product of this processing.

2.3 USES FOR AGGREGATES

Of the 151.4 million tonnes of primary aggregates consumed in England in 2005, the largest proportion was used in concrete (41 per cent). Direct constructional uses and fill used 30 per cent. Asphalt and roadstone (both coated with bitumen and uncoated) used 22 per cent. Six per cent went into the manufacture of mortar and the remaining one per cent was used for railway ballast. These proportions are illustrated on Figure 2.

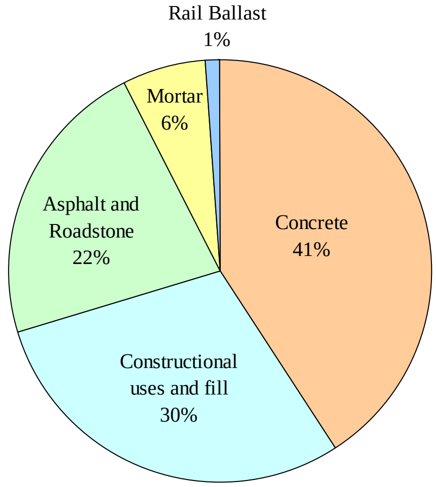


Figure 2 Uses of aggregates, 2005

Source: Mineral Extraction in Great Britain, 2005 (ONS, 2006a) and British Geological Survey

Concrete

Concrete is a mixture of aggregates, cement and water. The purpose of the aggregates within this mixture is to provide a rigid skeletal structure and to reduce the space occupied by the cement paste. Both coarse aggregates (particle sizes of 20 mm to 4 mm) and fine aggregates (particle sizes less than 4 mm) are required but the proportions of different sizes of coarse aggregates will vary depending on the particular mix required for each individual end use.

Concrete has been used, in some form, since Roman times and it is the most universal construction material around today. Usually it is supplied in one of two main forms: precast (blocks, tiles, pipes, bridge beams, flooring systems, etc) or ready-mixed (as a semi-liquid paste ready for pouring).

It is used for the foundations, walls, floors, roofs and partitions of buildings, as well as bridges, dams, power stations and many other kinds of physical structures. Often it is used in conjunction with other structural materials such as steel or brick. By controlling and modifying the proportions of the basic constituents, concrete is also highly adaptable and a wide variety of specialist concretes have been developed for particular uses.

Constructional uses & fill

Aggregates are used in construction to provide drainage, fill voids, protect pipes, and to provide hard surfaces. They are also used in water filtration and sewage treatment processes. Water will percolate through a trench filled with aggregates more quickly than it will through the surrounding soil, thus enabling an area to be drained of surface water. This is frequently used alongside roads in order to disperse water collected from the asphalt surfacing.

Voids created around the foundations of buildings during construction are filled with aggregates because it is easier to compact than the original soil that was removed, resulting in a more solid finish that will support the structure. Aggregates generally are not affected by the weather as much as soils, particularly clay soils, and will not suffer from shrinkage cracking during dry spells.

Pipes laid to convey treated water, or as conduits for cables, need to be protected from sharp objects in the ground and are therefore laid on, and surrounded by fine aggregates before trenches are backfilled.

Unpaved roads and parking areas are covered in a surface layer of aggregates to provide a more solid surface for vehicles, from cycles to lorries. This prevents the vehicles from sinking into the soil, particularly during wet weather.

Groundwater is filtered naturally through aquifers, often layers of sand and gravel, and only needs to be disinfected with chlorine before it is safe to use. This natural process can be replicated in treatment works to remove suspended solids from surface or stored water, before disinfection. In addition sand beds are used during the last stages of sewage treatment works as a final filter and cleaning process before the water is released into watercourses. In some cases reed beds are used at this stage, where the reeds will be grown on gravel.

Asphalt and roadstone

This category includes not just roads, but also pavements, airport runways, school playgrounds, car parks, most footpaths or cycleways, and other similar structures. Although each type of structure will require some variation in the material, it is useful to look at the basic structure of roads because they represent the bulk of the aggregates use in this category.

Roads are made up of a number of layers - from the bottom up these are:

- The subgrade - the natural soil, which will be compacted before the road construction starts.
- The capping layer - an optional layer, used when the local soils require extra strength, and it is not coated with bitumen.
- The sub-base - the main uncoated roadstone layer, its role is to give strength and act as a solid platform for the layers above.
- The binder course - the main load-bearing layer, provides an even plane for the surface course.
- The surface course - provides the road with protection from the weather because water ingress would be very destructive, but also gives the final running surface that must be resistant to abrasion and skidding.

The binder course (previously two layers known as the base course and roadbase) and surface course (previously known as wearing course) are commonly called ‘asphalt’, ‘coated roadstone’ or ‘tarmacadam’. They consist of coarse aggregates, with particle sizes typically between 2 mm to 28 mm, and fine aggregates, with particle sizes of less than 2 mm, mixed with a bitumen binder and occasionally some additional filler if required. The exact sizes required for the coarse aggregates will depend on the particular use and the asphalt recipe specified.

Increasingly, proprietary mixes are being developed known as ‘thin surfacing’ or ‘stone mastic asphalt’ which use cellulose fibres or specialist binders to obtain higher strengths with thinner layers of asphalt. These materials provide increased resistance to deformation where traffic density is high and also reduce surface water spray and vehicle noise.

Mortar

Mortar consists of sand, cement and water. In some circumstances lime may also be added, together with admixtures (chemicals to control setting and workability) and/or pigments if required. They are used to bond bricks or concrete blocks together in walls and to provide weather protection (known as rendering).

Railway ballast

A fully loaded train weighs a considerable amount (> 2 000 tonnes), added to this is the weight of the track itself and the sleepers it rests on. It soon becomes obvious that very tough aggregates are needed to support this weight and distribute the load of a passing train to avoid serious damage to the ground, or other structures, underneath. Similarly the railway track and sleepers must be held in place firmly and not move as a train passes along them.

Railway ballast generally consists of a tough igneous rock, such as granite, with large (40-50 mm size) angular pieces that lock together. Because of the way igneous rock is formed it is highly resistant to pressure and does not break easily.

Case Study 2 New Homes

Photos: BGS © NERC
Source: Housing Green Paper (CLG, 2007) and British Geological Survey

2.4 OTHER QUARRIED PRODUCTS

Materials extracted from aggregates quarries can also have important industrial uses. In particular, limestone is used in agriculture, iron and steel making, the chemical industries and for environmental uses such as cleansing emissions from power stations. These industrial uses have not been included within the analysis in this report; however, they do also contribute significantly to England's economy.

Also excluded from this report is the extraction of raw materials to manufacture cement. Cement is manufactured from limestone and clay or shale, by firing carefully controlled mixtures at a high temperature. The chemical composition of cement means that it reacts with water to form a paste which will set hard and bind all surrounding particles together (whether in concrete or mortar). Cement manufacture is the single most important industrial use of crushed rock (principally limestone).

There are several other minerals which are extracted in quarries similar to aggregates quarries, such as silica sand which is used in glass making or clay for brick and tile manufacture. These minerals are not considered further in this report. The industrial mineral fluorspar is the subject of a similar report entitled *The need for indigenous fluorspar production in England* (BGS, 2008a) which forms the second output from the project 'The need for non-energy indigenous mineral production in England'.

2.5 ALTERNATIVES TO AGGREGATES

A significant proportion of aggregates sales are used for the construction of buildings. But is it possible to construct buildings from materials other than aggregates?

Walking along an average city street, it would appear that alternative materials are used in construction. Many buildings are built from steel and glass, building stone or bricks. However, steel and glass buildings always require concrete foundations, often have a concrete frame (floors, supporting pillars, etc) and will also need drainage systems; all of which require aggregates. In addition, the steel itself comes from another mineral, iron ore, which will have been extracted from quarries or mines somewhere in the world. Glass is made primarily from silica sand, another mineral that has been extracted from a quarry, often in the UK.

Natural building stone has been used for building in the UK for over two thousand years. This material is also extracted from hard rock formations. A wide range of rock types have been used for building stone, including limestone and sandstone (sedimentary rocks) and granite (an igneous rock). The technical suitability of a rock for building stone is different from aggregates but they are still extracted from quarries. Construction with building stone is generally more expensive than other materials and it is doubtful whether adequate supplies of acceptable quality are available in the quantity that would be required to replace concrete.

Bricks are formed from clay and shale, also extracted from quarries, by drying and firing in a kiln. However, often the bricks seen in buildings are a 'facing' behind which the main structural load of the building is carried by concrete blocks, which are made from aggregates and cement.

Both building stone and bricks are held together in buildings by mortar. Mortar is made from sand and cement.

There are two important points to note from this discussion. Firstly, there are many uses for which there are no plausible alternatives to aggregates, for example in concrete, road surfacing or as drainage material. Secondly, even where there are alternatives such as steel, glass, bricks and building stone these still require some form of mineral extraction, have cost implications and result in issues surrounding adequacy of supply. Imports of these alternatives would incur the same problems as outlined later in this report.

In terms of resource efficiency, the consumption in England of just over 4 tonnes per person is the second lowest in Europe, with only Poland consuming less per person. The average amongst our European neighbours is nearly 10 tonnes per person.

The intensity of use of primary aggregates in construction in Great Britain has declined in recent years meaning that fewer primary aggregates are consumed per unit of construction than was previously the case (Figure 3). This is partly due to the increasing use of secondary and recycled aggregates, derived mainly from construction and demolition waste, but also reflects the increased use of steel and glass in construction and greater efficiency of use (i.e. less waste) of materials at construction sites. It probably also reflects a wide range of other factors that are unrelated to aggregates use, not least the more complex (and therefore more costly) nature of modern buildings.

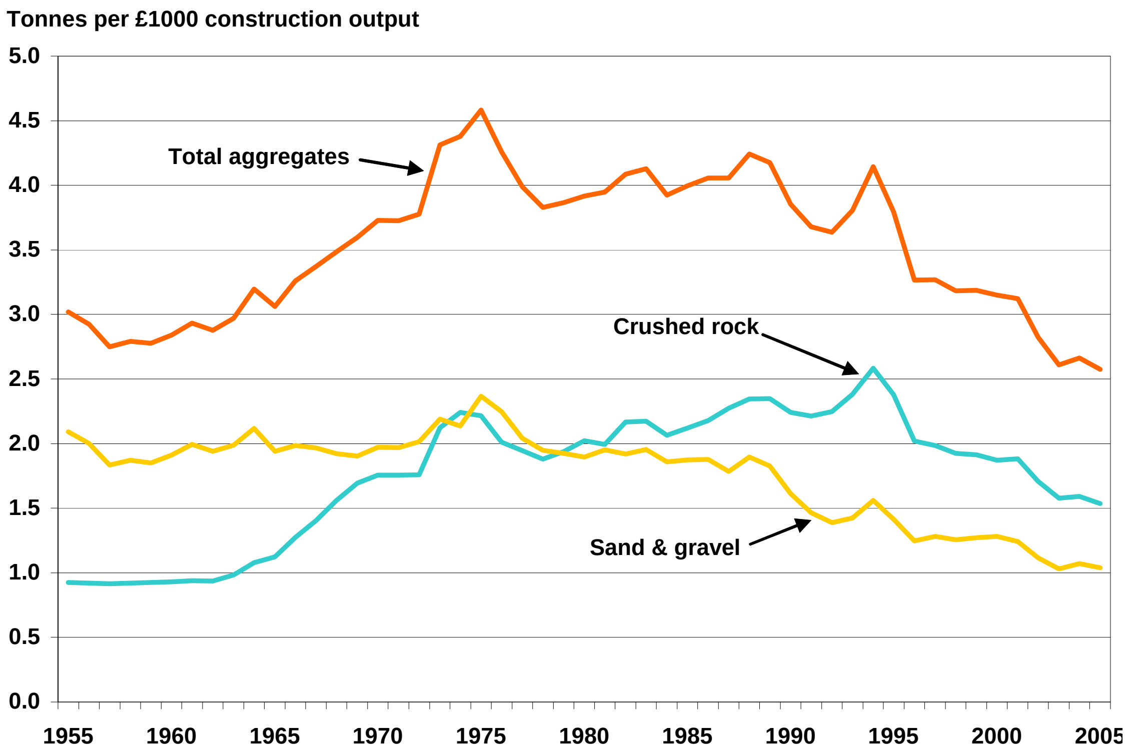


Figure 3 Intensity of use of primary aggregates in Great Britain

Source: UK Minerals Yearbook (BGS, 2007b)

However, there is limited practical potential for the further minimisation of demand through efficiency savings and therefore this reduction in intensity of use cannot continue indefinitely.

The quantities of secondary and recycled aggregates used in construction have increased in recent years and currently represent 26 per cent of the aggregates consumed in England. Estimates vary of the maximum proportion this may rise to, but it is likely these materials will not increase beyond 30 per cent of England's total requirement for aggregates (WRAP, 2006).

Construction will always require aggregates and there are not sufficient quantities of secondary and recycled materials to meet all of this need.

3 Economic Benefits of Aggregates

3.1 CONTRIBUTION TO ECONOMIC OUTPUT

The most obvious contribution made by any sector to the economic output of England is its ‘direct contribution’. Wealth is created and employment is sustained as a result of customers purchasing aggregates. However, the contribution of any sector to the economy extends beyond this due to links between different industries, as shown in Figure 4. The overall benefit to the economy is considerably greater due to these ‘indirect contributions’.

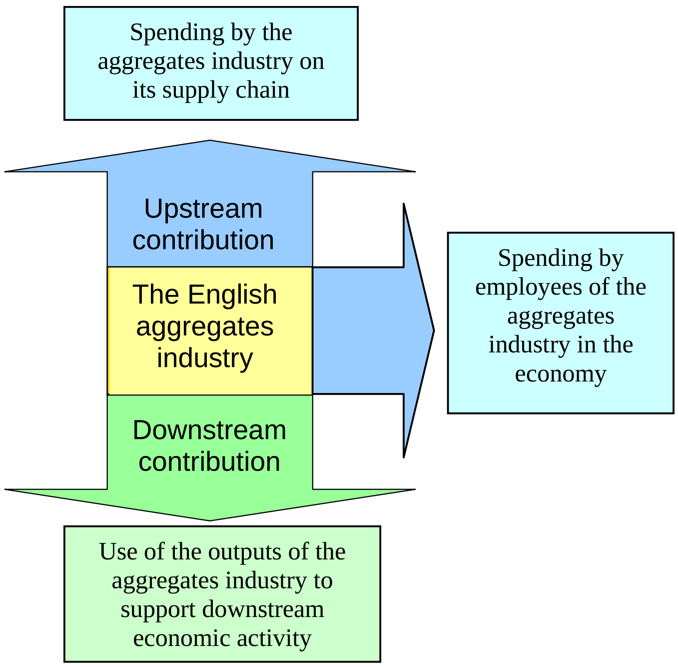


Figure 4 Links between the aggregates industry and other parts of the economy

As the figure illustrates, the ‘indirect’ contributions of the aggregates industry can be divided into three components:

- **The upstream contribution.** The aggregates industry requires various inputs in order to operate. These include a wide range of goods and services, such as fuel and transport. Acquiring inputs generates economic activity and employment in supplying industries.

- **Employee spend contribution.** The part of the wages and salaries that employees of the aggregates industry spend on consumer goods and services, rather than save, also supports economic activity and employment in other sectors.

- **The downstream contribution.** Aggregates are an essential input into many downstream industries which, in turn, generate economic activity and employment. Most notable among these are the construction products industries (such as concrete, asphalt and mortar) and the construction industry.

There is a difference between the first two of these links and the third. If the English aggregates industry did not exist, the contributions of these first two to the economy would be lost in their entirety. Although, over time, suppliers would be expected to supply different industries and employees to find new jobs, these would be expected to be less productive or less remunerative.

However, it is not the case that the entirety of the downstream activity would be lost because other materials are purchased by the downstream industries in order to produce their outputs. Therefore, although the economic benefit of the aggregates industry in supporting downstream activities needs to be taken into account, this cannot be done by adding estimates of this activity in the same way that can be done for the upstream and employee spend contributions. Customers would endeavour to purchase their aggregates requirements from other sources (such as imports) or use alternative materials. However, for some requirements of the construction industry there are no alternatives to using aggregates.

3.2 MEASURES OF ECONOMIC CONTRIBUTION

Gross output, or turnover, represents the total value of sales produced by an industry within a period of time. However, economic benefit is often measured in terms of 'Gross Value Added' (GVA) which is defined as gross output minus the value of goods and services used to produce that output. Therefore, the GVA generated by an industry is approximately the sum of the remuneration of employees and profit generated by that industry. There is a very close link between GVA and 'Gross Domestic Product' (GDP). Specifically, GVA at current basic prices, plus taxes on products, less subsidies on products, is equal to GDP at current market prices. The GVA of an industry or region can be thought of as its contribution to national GDP.

Employment is defined in terms of the number of jobs that the aggregates industry sustains, including both full time and part time jobs. A full explanation of the methodology used to derive these direct contributions, i.e. national accounts definitions and allocation rules, is provided in Appendix 1.

New terminal buildings, air traffic control tower, 4000 space multi-storey car park, and over 13 km of tunnelling

London Heathrow Terminal 5

30 million passengers per year

16,500 new jobs

£4.2 billion investment

Over 1.5 million cubic metres of concrete, using

Over 3 million tonnes of aggregates

Additional aggregates were also used to manufacture 105,500 precast concrete tunnel lining segments, and for road improvements

Case Study 3 London Heathrow Airport, Terminal 5

Photos: © British Airports Authority (used with permission) www.baa.com/photolibrary

Source: British Airports Authority website, and http://www.airport-technology.com/projects/heathrow5/

3.3 DIRECT BENEFITS OF THE AGGREGATES INDUSTRY

It is calculated that the primary aggregates industry (i.e. excluding secondary and recycled materials) directly contributed £810 million to the English economy in 2005 in terms of gross value added (based on 2005 prices). This is equivalent to 0.12 per cent of total English GVA. Direct turnover of the industry was £2480 million which is also approximately 0.12 per cent of the total turnover in the English economy.

Figure 5 shows how the GVA of the aggregates industry has changed in recent years (using constant 2005 prices). Direct GVA from aggregates rose between 1999 and 2001, from around £570 million to £720 million. However, GVA is estimated to have fallen sharply in 2002 to just under £500 million, a drop of over 30 per cent. Since 2002 real GVA from aggregates has risen by over 60 per cent to £810 million. Over half of this growth was due to a strong performance in 2005. GVA as a share of England's total GVA grew at a similarly strong pace between 2003 and 2005, following a significant fall in 2002.

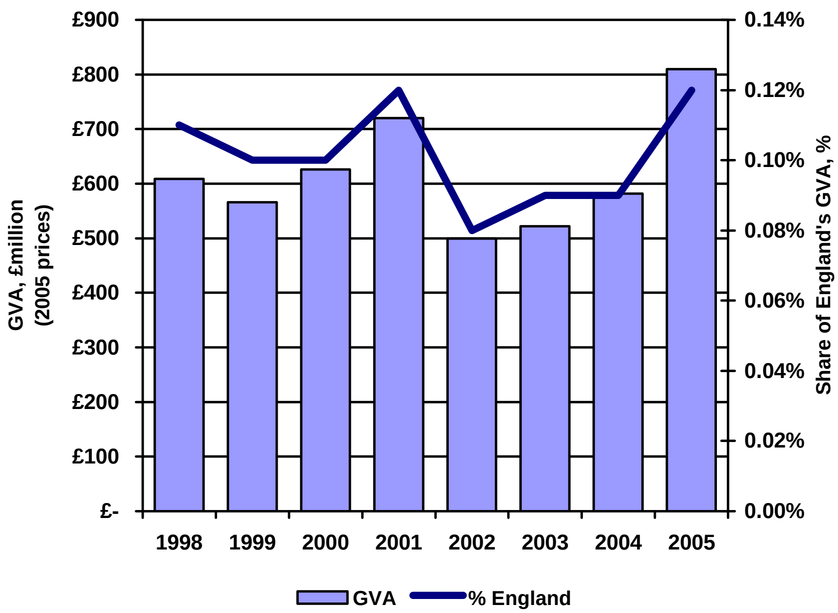


Figure 5 Real GVA from the aggregates industry (2005 prices), England, 1998-2005

Source: Annual Business Inquiry 2005 (ONS, 2006b) and cebr analysis

As a direct result of aggregates extraction, the industry also supported 8300 jobs in England in 2005. Employment in the industry has declined at a gradual pace from 9100 people in 1998, a fall of just under nine per cent (Figure 6). However, this employment reduction occurred at the same time that GVA rose by around 33 per cent, indicating a significant improvement in labour productivity over this period.

This figure excludes downstream industries directly utilising aggregates, such as concrete, coated roadstone, etc. If all these are included the number of people employed rises to nearly 30 000 in 2005. It also excludes self-employed hauliers and contractors who may be employed solely by the aggregates industry.

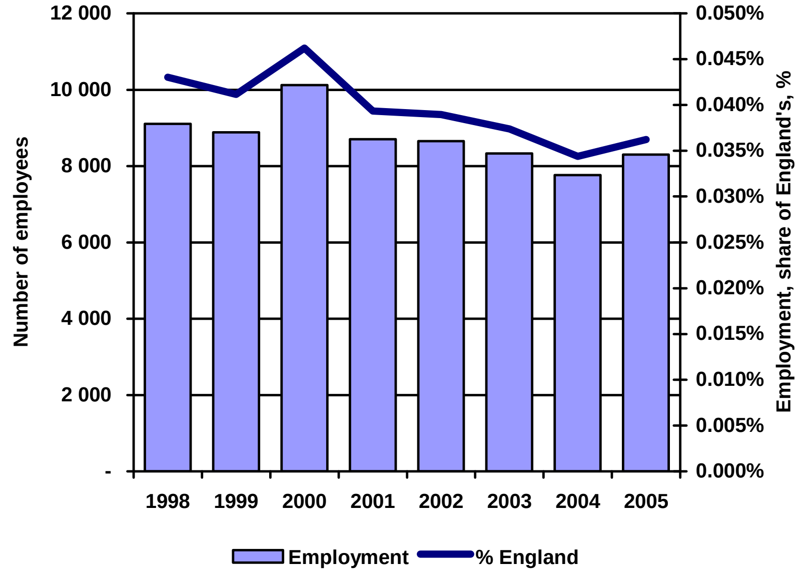


Figure 6 Employment from aggregates industry, England, 1998-2005

Source: Annual Business Inquiry 2005 (ONS, 2006b) and cebr analysis

Case Study 4 Two high schools in Leicestershire

Photos: © Leicestershire County Council, Property Services (used with permission)
Source: Leicestershire Council Council (www.leics.gov.uk) and Wilmott Dixon (by correspondence)

Aggregates production varies considerably from region to region, due to the geology of the country and competing land uses. Therefore the GVA from the aggregates industry also varies by region. Figure 7 shows estimated direct GVA by region and a number of trends are apparent from this graph. Firstly, throughout most of the period shown similar regions have remained the most significant for the industry; these are the East Midlands, East of England, South East and South West. By contrast, throughout most of the period, economic activity in London has been below that of other regions. This is because London produces only a small amount of aggregates.

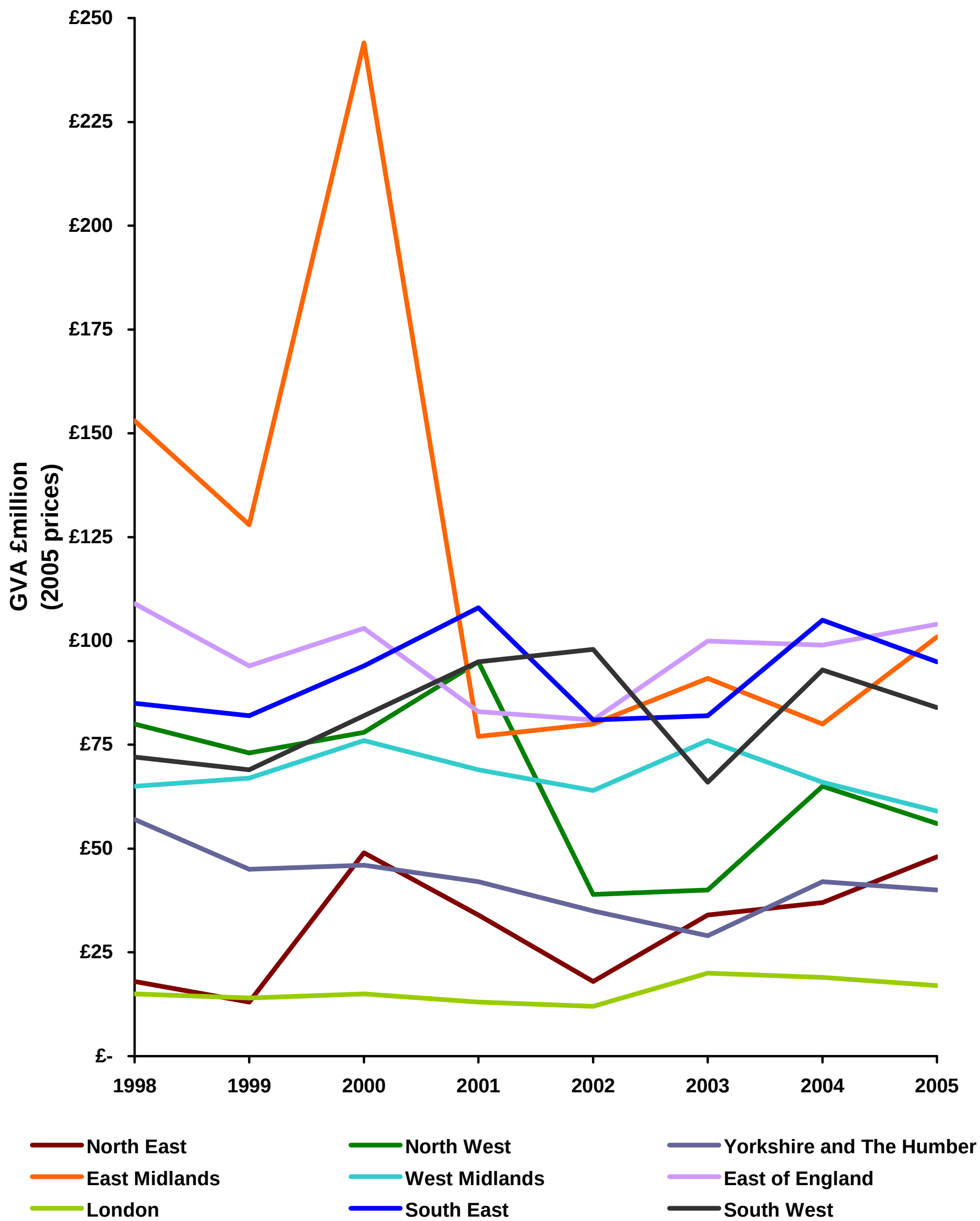


Figure 7 Real GVA from the aggregates industry (2005 prices), by region, 1998-2005

Source: Annual Business Inquiry 2005 (ONS, 2006b) and cebr analysis

There appears to be a sharp peak in GVA for the East Midlands in 2000 when the Annual Business Inquiry (ONS, 2006b) suggests that employment increased by more than 66 per cent in one year, thereby also increasing GVA. This has been followed by a significant fall the following year, which perhaps indicates a problem with the raw data. However, even ignoring this peak it would appear the real GVA for the East Midlands has declined since 1998, although there is some evidence of a pick-up in activity in 2005.

The largest increase in activity has been in the North East, where real GVA has increased by and estimated 165 per cent during the period shown. The average growth amongst the other regions is 38 per cent.

It is also possible to present these data as a proportion of total regional GVA, as shown in Figure 8.

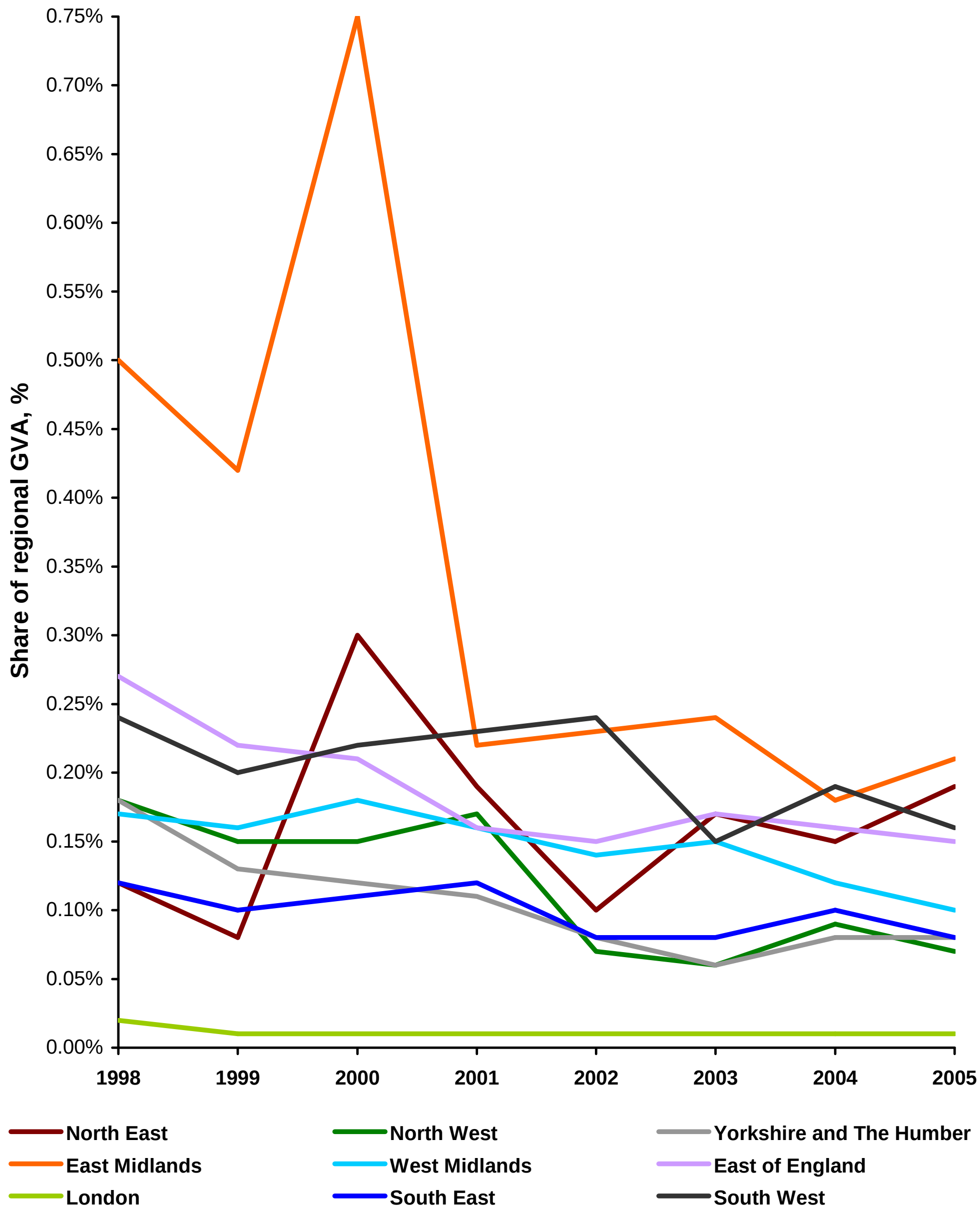


Figure 8 Aggregates real GVA as a percentage of regional GVA, 1998-2005

Source: Annual Business Inquiry 2005 (ONS, 2006b) and cebr analysis

This graph again shows the decline in activity levels of the aggregates industry in the East Midlands: in 1998 it contributed to 0.5 per cent of the East Midlands' total economic activity but only 0.2 per cent in 2001, where it has remained broadly since. Nonetheless, the East Midlands is still the region where the aggregates industry makes the largest contribution to economic activity.

In recent years the aggregates industry has become more important to the North East economy. Aggregates also contribute a large share to the South West's economy, when compared to other regions. It is again apparent that the industry plays only a very small role in the London economy.

In the same way, levels of employment can be split by region as shown in Figure 9 (for absolute levels of employment by region) and Figure 10 (as a proportion of total employment in a region). These graphs show a broadly similar picture to the GVA graphs. In terms of absolute levels of employment, there is a clear grouping at the top with the South East, South West, East Midlands and East of England employing the most people. In each of these regions there were at least 1200 jobs in the aggregates industry in 2005.

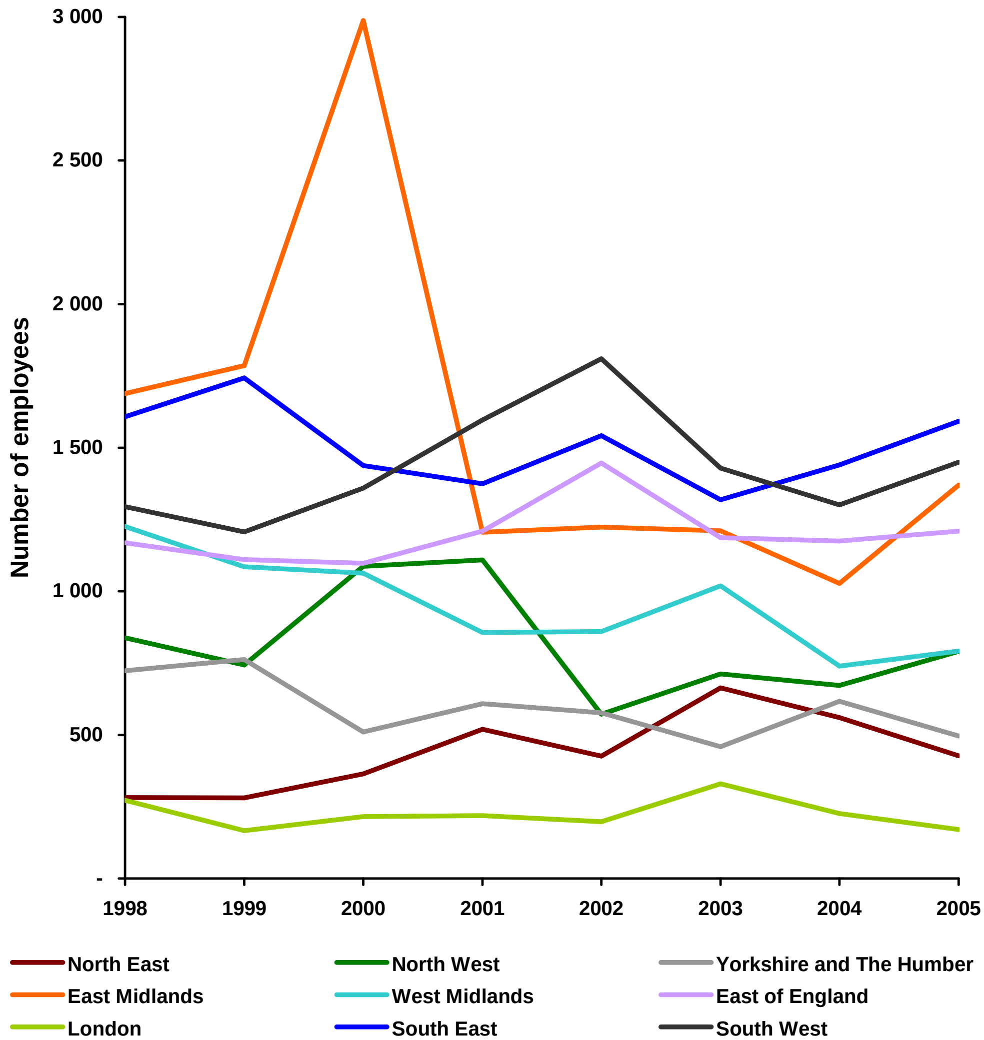


Figure 9 Direct regional employment in the aggregates industry

Source: Annual Business Inquiry 2005 (ONS, 2006b) and cebr analysis

Considering employment as a proportion of total employment in each region, the aggregates industry remains most important in the East Midlands and South West, compared to other regions. As with GVA, the importance of the industry in the North East is more marked when employment is considered as a proportion of the total employment in the region. As would be expected, London's aggregates industry is less significant to the region.

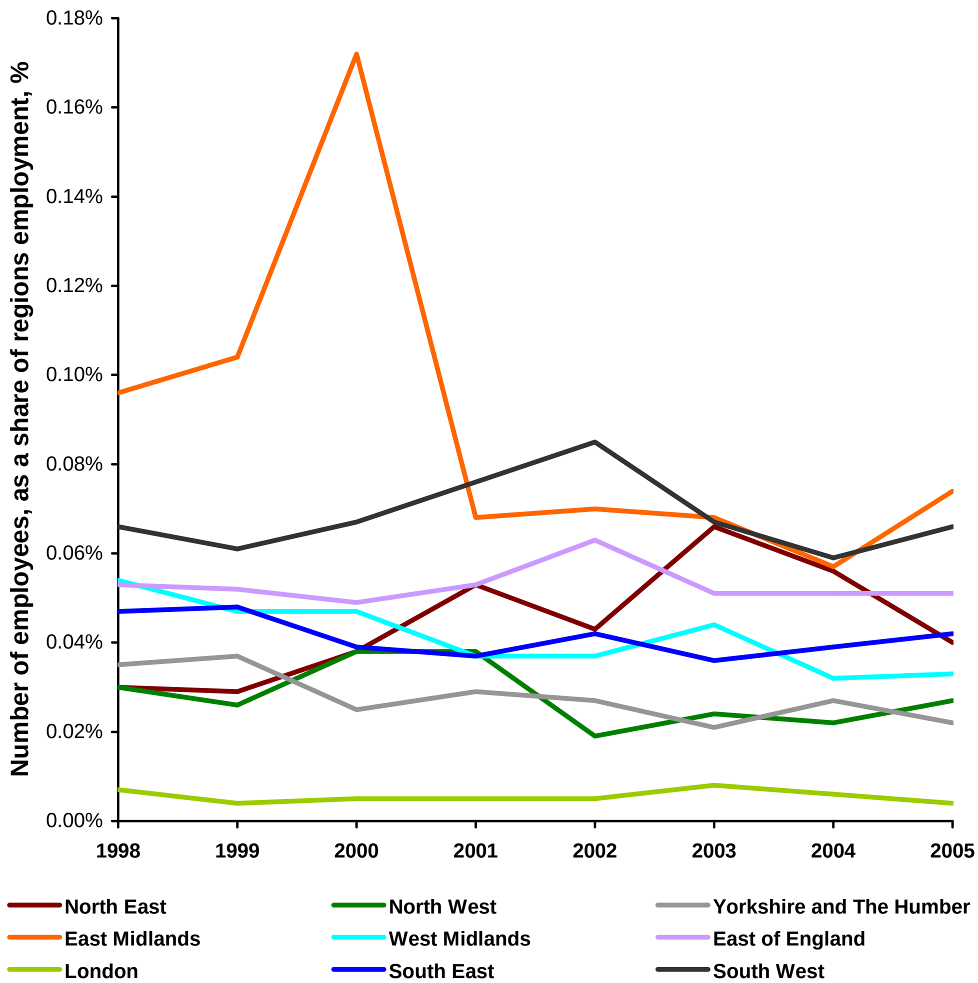


Figure 10 Contribution of aggregates industry to regional employment

Source: Annual Business Inquiry 2005 (ONS, 2006b) and cebr analysis

3.4 UPSTREAM CONTRIBUTION OF THE AGGREGATES INDUSTRY

The upstream contribution of the aggregates industry to the economy is as a result of purchasing goods and services from its suppliers. This can be derived from input-output table analysis.

Input-output tables (ONS, 2007a) analyse the pattern of spending relationships between different parts of the economy, i.e. how much sector A spends on the outputs produced by sector B. The expenditure contribution can then be traced into GVA and employment.

It has been estimated that the English aggregates industry spent approximately £753 million with its suppliers in 2005. In order to avoid double-counting, this figure excludes all spending by the aggregates industry within the 'other mining and quarrying sector', of which only some will be with other aggregates firms and hence included in the direct figures discussed above. As such, this represents a **conservative**, i.e. low, estimate.

By understanding the relationship between the amount spent in these industries and the GVA and employment of these industries, estimates of the levels of upstream GVA and employment that is supported by the aggregates industry can be derived. In 2005 the £753 million spent by the English aggregates industry led to £188 million of GVA in the economy. Similarly, spending by the aggregates industry led to 4680 additional jobs. These results are shown in Figure 11.

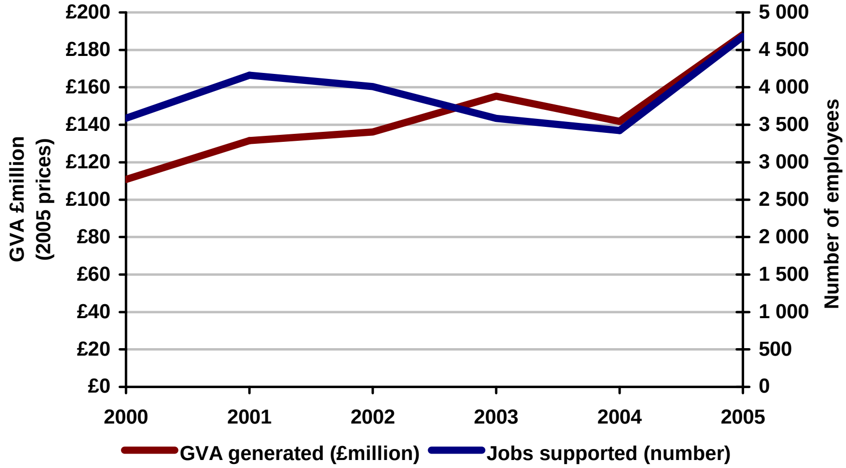


Figure 11 Upstream GVA and jobs supported by the aggregates industry

Source: ONS (2007a) and cebr analysis

The upstream GVA resulting from the aggregates industry has risen from approximately £110 million in 2000 to £188 million in 2005 (based on 2005 prices). The number of jobs supported by this activity rose to 3590 in 2001 but dropped slightly until 2004 before rising again to 4680 employees in 2005.

It is also possible to evaluate in which industries this economic activity and jobs are being supported by looking at which supplying industries the aggregates industry is spending in. This is shown in Figure 12 for 2005.

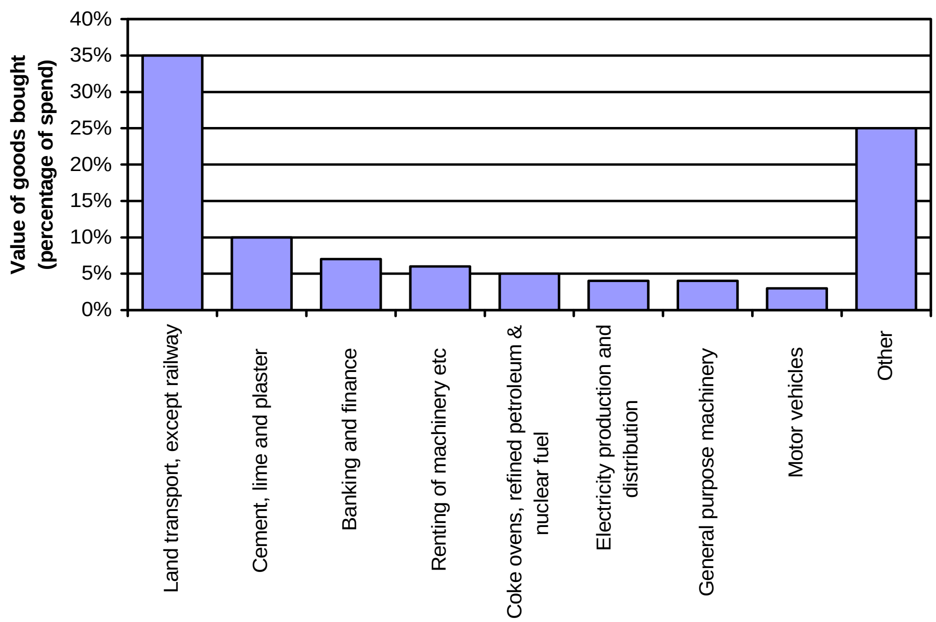


Figure 12 Breakdown of goods and services bought by the aggregates industry

Source: ONS (2007a) and cebr analysis

By a considerable margin, the aggregates industry buys the most goods and services from the land transport (excluding railway) sector, i.e. road haulage. Other industries which benefit from spending by the aggregates industry include cement, lime and plaster producers, the banking and finance sector and energy providers.

3.5 EMPLOYEE SPEND CONTRIBUTION OF THE AGGREGATES INDUSTRY

Direct employees of the English aggregates industry support economic activity as a result of spending of their wages and salaries. This creates a demand for goods and services from other parts of the economy. Estimates of the amount of this spend, the GVA it generates and the jobs it supports are shown in Figure 13.

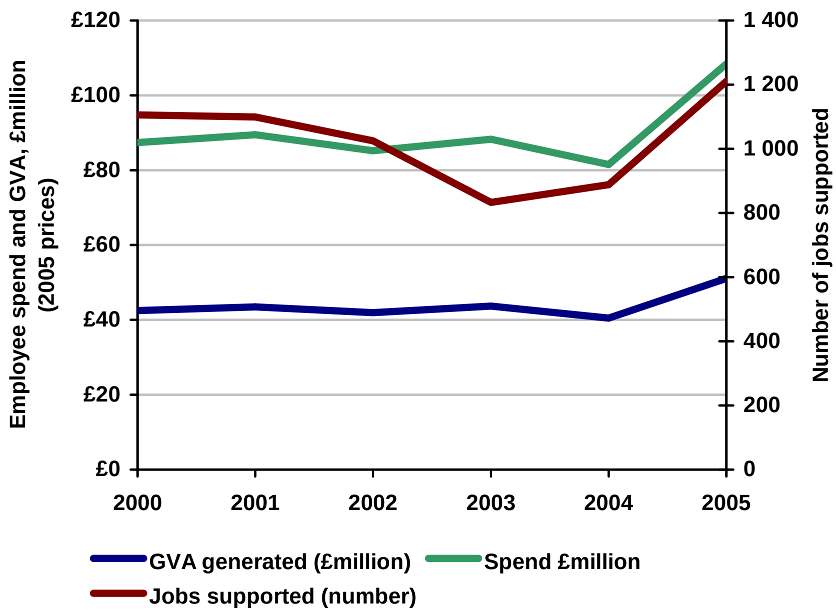


Figure 13 Employee spend and associated GVA generated by the English aggregates industry, together with the number of jobs supported

Source: ONS (2007a) and cebr analysis

The figure shows that the amount of spend by direct employees in the English aggregates industry remained between £85 million and £90 million per annum between 2000 and 2004. However, in 2005, as the industry's direct economic output level increased, the amount of spend by employees also increased to £108 million.

The GVA generated as a result has remained nearly constant in real terms at just over £40 million until 2004 but has risen to £51 million in 2005. The jobs supported by the spending of England's aggregates industry employees has fallen from 1000 in the year 2000 to less than 900 in 2004. This is consistent with labour productivity improvements in the sectors in which the aggregates employees are spending. The number of jobs supported rose to 1200 in 2005.

Figure 14 shows the industries where aggregates employees spend their wages and salaries. The highest spending destinations are given. Perhaps not surprisingly, this shows that the aggregates employees are primarily supporting jobs in the retail and distribution sector.

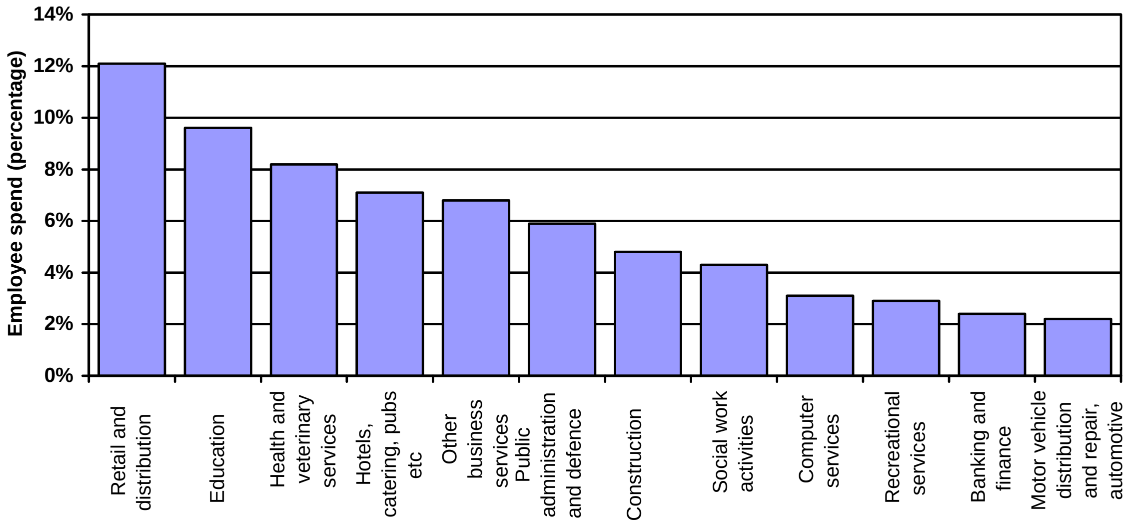


Figure 14 Breakdown by sector of activity supported by aggregates industry employees, 2005

Source: ONS (2007a) and cebr analysis

Case Study 5 The M6 Toll road

Photos: © Midland Expressway Ltd (used with permission)

Source: M6 Toll website www.m6toll.co.uk, and BGS estimate

3.6 DOWNSTREAM CONTRIBUTION – CONSTRUCTION PRODUCTS

Although aggregates are used directly, for example as a drainage medium, rail ballast or fill material, a large proportion is used in the manufacture of construction products. These include ready mixed concrete, coated roadstone, mortars and concrete products such as pipes, roof tiles, paving slabs or beams. Most of these products are used by the construction industry as shown in the figure below. (The construction industry itself is considered further in the next section).

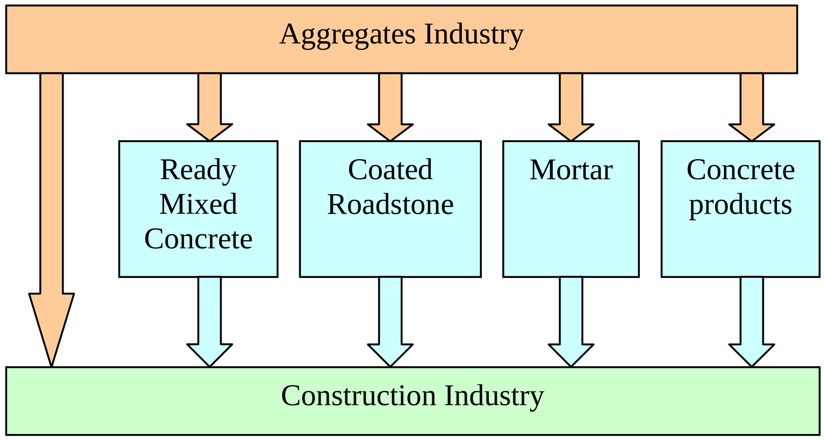


Figure 15 Relationship between the aggregates industry, the main construction products and the construction industry

These construction products industries are dependent upon supplies of aggregates from the aggregates industry. Without them, they could not produce their own outputs. Therefore it is appropriate to consider the GVA and employment contributions by these industries to the English economy. These are shown in Table 2 below.

2005	**GVA £million**	**Employment (number of jobs)**
Ready mixed concrete	164	3 977
Coated roadstone	65	370
Mortar	17	280
Concrete products	951	16 837
Total	**1 197**	**21 464**

Table 2 GVA and employment contribution of construction products industries

Source: ONS (2006b) and cebr analysis

3.7 DOWNSTREAM CONTRIBUTION – THE CONSTRUCTION INDUSTRY

Aggregates provide an essential input into the construction industry; all building projects will require some quantity of aggregates. In addition, construction is not like manufacturing in that it cannot be moved overseas. However, simply summing up the economic contribution of the construction industry to all the other downstream industries reliant on aggregates and attributing this to the aggregates industry is not appropriate because the construction industry also uses other materials and the entirety of the industry would not be lost if there were no indigenous aggregates supply. There would still be a demand for things to be built.

Therefore, the downstream value of the construction industry, in relation to aggregates, needs to be considered in a different way. Four pieces of analysis are included here:

1. The importance of the construction industry to the English economy;
2. The links between the aggregates and construction industries;
3. The sensitivity of the relationship between aggregates prices and non-housing construction activity; and
4. The impact of increasing aggregates prices on the construction of houses.

3.7.1 The importance of the construction industry

The construction industry is an important component of the English economy both in terms of GVA and employment, as shown in Figure 16.

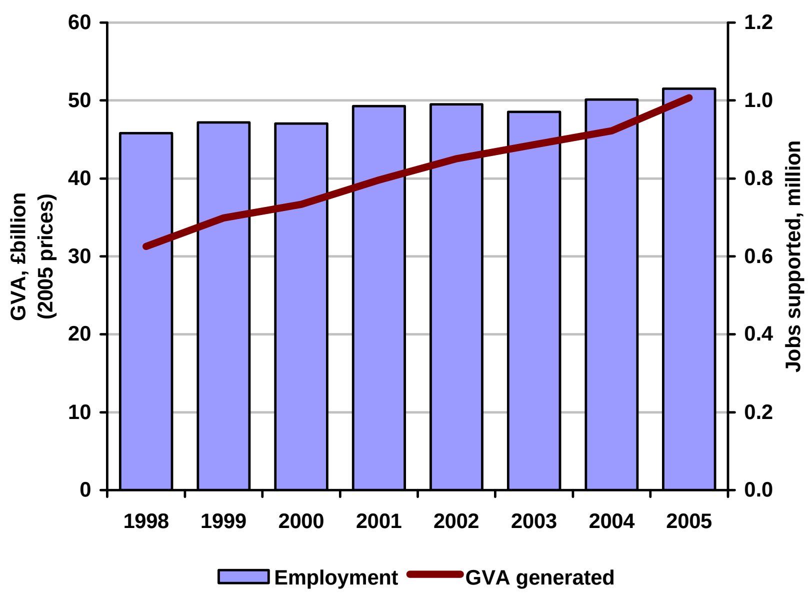


Figure 16 Real GVA and employment generated from the construction industry

Source: Annual Business Inquiry 2005 (ONS, 1006b) and cebr analysis

There were just over one million people employed in the construction industry in 2005 in England. Employment in the industry has risen gradually since 1998, when it stood at 916 000. Between 1998 and 2005 the annual rate of growth of employment in the industry averaged 1.7 per cent. Over the period employment grew by 12.4 per cent.

Real GVA from the sector also rose between 1998 and 2005, rising by 60.9 per cent. During this period England GVA from construction rose from £31.3 billion in 1998 to £50.4 billion in 2005, implying an average annual growth rate of 7.1 per cent.

The importance of the construction sector as a proportion of total English GVA and employment is shown in the Figure 17. In the eight years examined, the construction industry has employed between 4.3 and 4.5 per cent of England's workforce. In terms of GVA, the contribution is even more significant and is also increasing. In 1998 the construction sector contributed 5.6 per cent to the English economy but this has risen to 7.5 per cent in 2005.

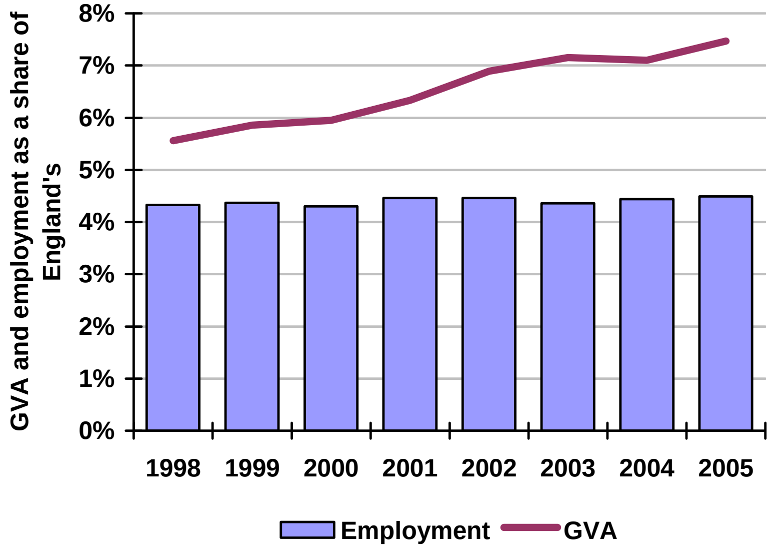


Figure 17 English construction industry GVA and employment as a proportion of English totals

Source: Annual Business Inquiry 2005 (ONS, 1006b) and cebr analysis

To place this in context, this is broadly the same contribution as was made by all retailers (except motor vehicles and motorcycles), which contributed £51.1 billion to the English economy in 2005, as shown in Table 3.

Sector	**Contribution to English economy**
Retail trade except of motor vehicles and motorcycles; repair of personal and household goods	£51.1 billion
Construction	£50.4 billion
Computer and related services	£31.5 billion
Post and telecommunication	£31.0 billion
Hotels and restaurants	£24.4 billion
Real estate activities	£22.9 billion

Table 3 Contribution of sectors to the English economy

Source: Annual Business Inquiry 2005 (ONS, 1006b)

3.7.2 The links between the aggregates and construction industries

Considering the situation first from the perspective of the aggregates industry, it is clear that the construction sector is easily the most important purchaser of aggregates industry products (as shown in Section 2). It is estimated that approximately 90 per cent of aggregates produced are sold to the construction industry, either directly or indirectly through construction products such as concrete.

From the perspective of the construction industry, Figure 18 is a breakdown by value of the sectors from which the construction industry purchased materials. Only the nine largest sectors are shown.

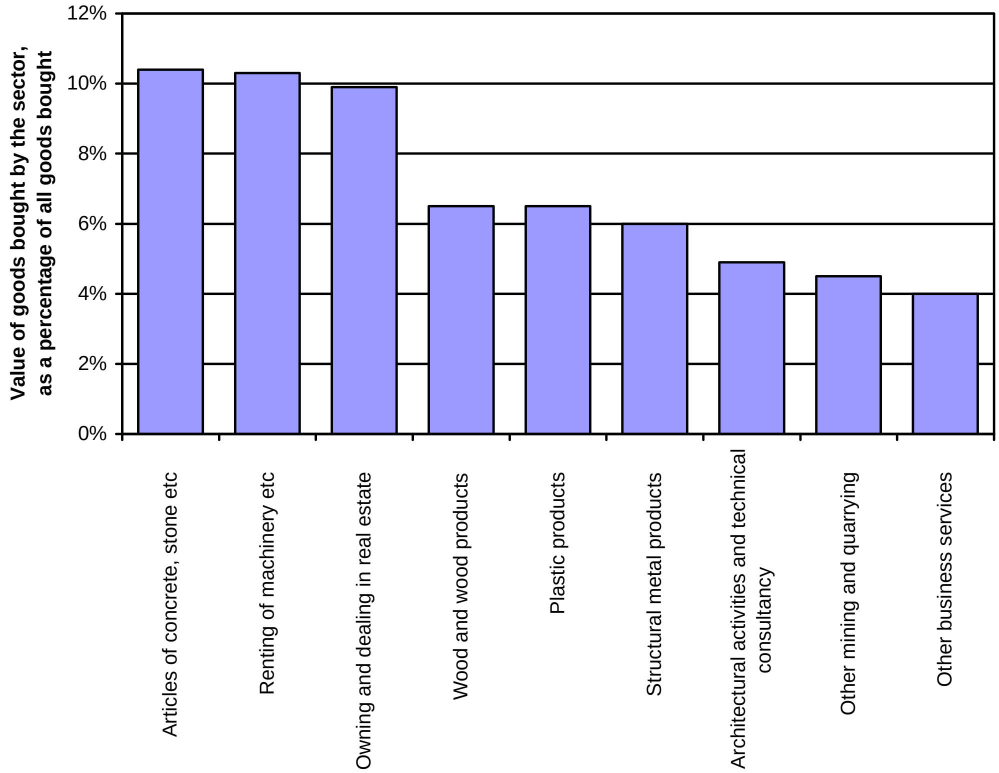


Figure 18 Breakdown by sector of inputs purchased by the construction industry, United Kingdom, 2005

Source: ONS (2007a) and cebr analysis

On first appearances, "Other mining and quarrying", of which aggregates represents over ninety per cent, is only the eighth most important supplier to the construction industry with the construction industry buying more from the wood, plastic and metal products sectors. However, this ignores the importance of purchases of "articles of concrete, stone, etc" which is the most significant supplier to the construction industry, constituting more than 10 per cent of their purchases by value. As aggregates represent a significant input into this industry, the overall role of aggregates in supplying the construction industry is much greater. In total the "other mining and quarrying" and "articles of concrete, stone, etc" combined represent 14.4 per cent of the spending of the construction industry. This was the equivalent of £8.1 billion in 2005.

The significance of the aggregates industry in providing a vital input into the construction sector is further emphasised by the quantity of aggregates that have been required in infrastructure developments in recent years and other building projects, as shown in section 2 of this report and the case studies throughout this document.

3.7.3 The sensitivity of construction activity to aggregates prices

Previous sections have looked at the importance of the construction industry, and the links between it and the aggregates industry. This section attempts to quantify the sensitivity of this relationship. One way of looking at this is to see what would happen in the construction industry if there was shock, e.g. a price rise, in the aggregates industry.

The term 'elasticity' is used to describe changes in one variable (such as demand or output) as a result of variation in another factor (such as price). Demand is described as 'inelastic' if it does not vary by much even though prices increase. In contrast demand is considered to be 'elastic' if there is a significant change as a direct response to a variation in price.

An 'econometric' model was used to assess the elasticity of non-housing construction output with respect to aggregates prices. Full details of this model can be found in Appendix 2. The elasticities of non-housing construction output, in both the short run and long run, are shown in Table 4.

Factor	Construction costs	GDP	Interest rates
Short run elasticity	0	2.83	0
Long run elasticity	-0.16	0.53	0

Table 4 Estimated elasticities of non-housing construction output with respect to certain key variables

Source: cebr calculations

The key results from the model from the perspective of this report are the fact that the modelling suggests that there is a **negative** relationship between construction costs and construction activity in the long term. Specifically, it suggests that **a one per cent increase in construction costs leads to 0.16 per cent decline in construction output.** The model suggests that the effect of a change in construction costs feeds through to construction output within two years. In line with expectations, the model does not suggest that construction costs have any short term effect i.e. one quarter to the next on construction output. This is to be expected given the long lags in the construction sector which prevent companies responding flexibly to changing input conditions.

In terms of the implications of this analysis for aggregates, it is estimated from input-output table analysis that approximately 2.0 per cent of the total spending by the construction sector is influenced by the price of aggregates (including spend on construction products). Using this ratio, it is possible to calculate the potential implications for non-housing construction output. Table 5 assumes that the base cost of aggregates is £12 per tonne and uses the 2006 value of non-housing construction output of £30.6 billion.

Aggregates costs (£/tonne)	Percentage increase in aggregates cost	Percentage change in construction costs	Percentage change in non-housing construction output	Change in non-housing construction output, £m
13	8.33	0.17	-0.03	-8.29
14	16.67	0.34	-0.05	-16.58
15	25.00	0.51	-0.08	-24.86
16	33.33	0.68	-0.11	-33.15
17	41.67	0.85	-0.14	-41.44

Table 5 Estimated change in non-housing construction output from a change in aggregates prices

Source: cebr calculations

These calculations suggest that increasing the cost of aggregates by one pound per tonne leads to a long term reduction in non-housing construction output of approximately 0.03 per cent. Based on the 2006 value of non-housing construction output, this equates to an estimated reduction in non-housing construction output of approximately £8 million for every pound increase in the cost of a tonne of aggregates.

In comparison to the value of construction output, these effects can be regarded as small. This reflects the low cost of aggregates in relation to the value of the buildings and structures produced.

3.7.4 The impact of increasing aggregates prices on the construction of houses

The construction of new homes is of considerable importance for public policy. A recent government green paper states that:

> ‘if we ignore the rising pressure for more homes, we will see widening wealth inequality, frustrated aspirations and damage to our economy. And unless we do more to improve housing for growing children, we will be denying too many of them a good start in life.’ (CLG, 2007)

The green paper sets a target for completions of 240 000 new homes per annum by 2016.

In order to analyse the impact of aggregates prices on the construction of new homes, a ‘market-model’ was developed. Full details of the type of model and assumptions used are available in Appendix 3. Figures 19 and 20 show the predictions of the model in terms of the long-term percentage change in the price of new homes and in completions of new homes. Price increases of between £1 and £12 per tonne have been considered, with intensity of use varying between 60 tonnes per house (assuming no construction of roads or other infrastructure is required) and 450 tonnes per house.

The modelling suggests that a restriction in the supply of aggregates would be expected to lead to an increase in the price of new houses and a reduction in the number of housing completions in the long-term. Given the relatively low cost of aggregates, particularly when compared to the overall price of a typical house, the effects are not substantial. For example, a price rise of £4 per tonne of aggregates, based on 300 tonnes per house, would result in a price increase of only 0.61 per cent per house and a reduction in completions of 0.24 per cent. Given that the average new house price is broadly in the region of £200 000 (BBC, 2008), this suggests a long-term increase in the price of a new home of around of £1,200. However, if average house prices were to fall significantly in the currently changing market conditions, the impact of a major aggregates price rise would be magnified.

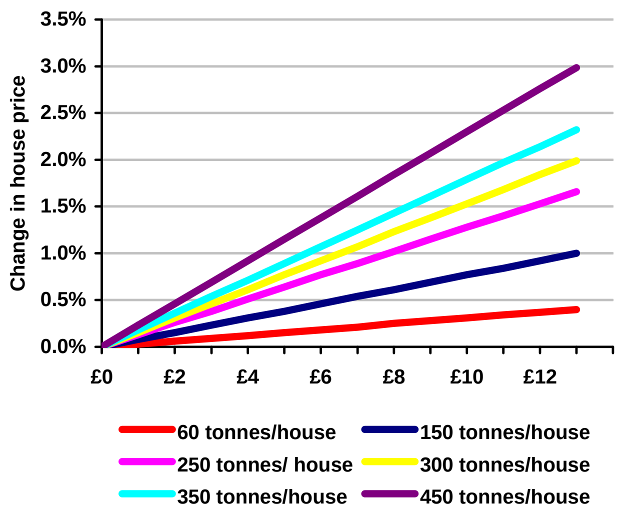


Figure 19 Estimated long-term change in the price of a house from increasing the price of aggregates
Source: cebr calculations

In practice there are many factors that determine whether new homes are constructed or not and these may carry more weight than the cost of raw materials. The cost of aggregates in particular is probably of much less concern to the house-builder than many other types of expenditure, due to the relatively low prices for these materials in comparison to the value of the new house. However, restricting the supply of aggregates, and hence increasing their price, could have an adverse impact on the number and affordability of new homes coming to market, at a time when government policy is explicitly focused on realising improvements in these areas.

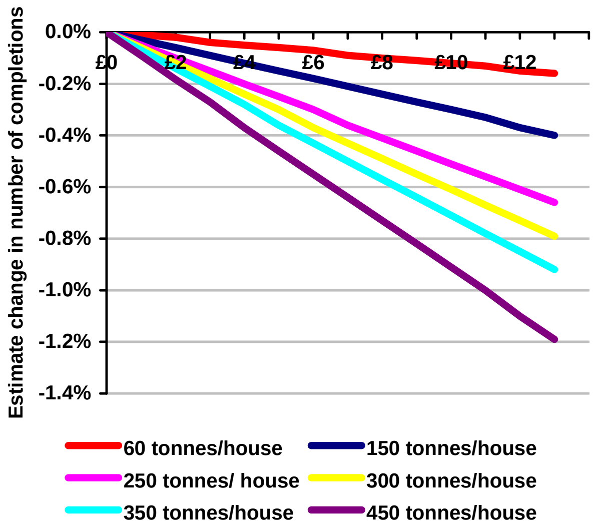
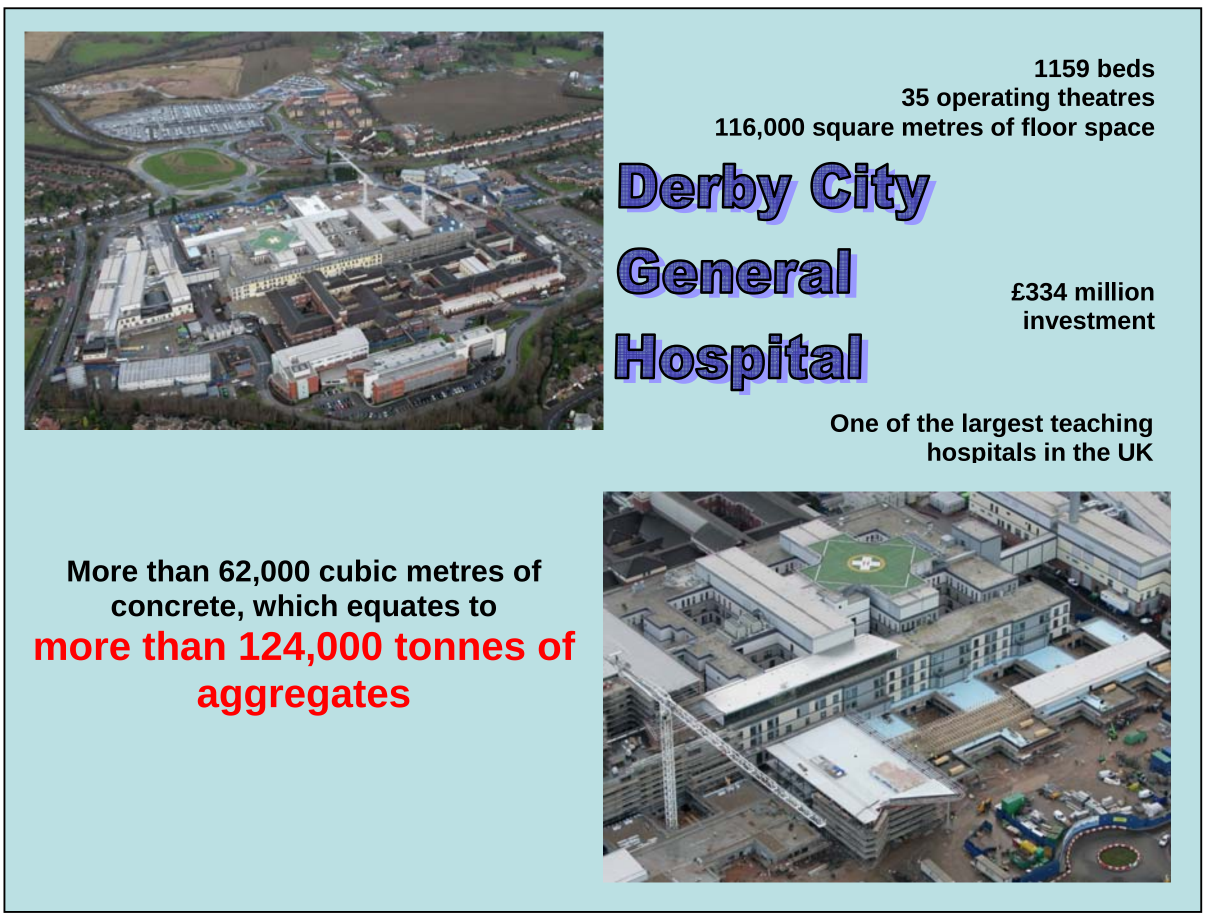


Figure 20 Estimated long-term change in the number of completions per annum from increasing the price of aggregates
Source: cebr calculations



Case Study 6 Derby City General Hospital

Photos: © Derby Hospitals NHS Foundation Trust (used with permission)
Source: Derby Hospitals website http://www.derbyhospitals.nhs.uk/newhospital/newhospital.html and Skanska Integrated Projects (by correspondence)

3.8 INFRASTRUCTURE AND ECONOMIC GROWTH

The previous section considered the role of the aggregates industry in providing an input into the construction industry. This showed that the construction industry accounts for more than 7 per cent of the GVA of England and employs just over one million people.

However, the importance of the construction industry, and hence the aggregates industry in providing inputs to construction, extends beyond the direct contribution to employment and GVA. The outputs of the construction industry, particularly housing and infrastructure, are likely to be vital if other aspects of the economy are to function well and economic growth is to be facilitated.

The link between infrastructure investment and economic growth in developed countries is complex. Although there is a large consensus on the existence of a definite link between these two variables, there has been some debate over whether infrastructure investment causes economic growth or whether strong economic growth results in investment in infrastructure (see Appendix 4 for further details of this debate).

The most recent studies on this have concluded that improved infrastructure both increases economic growth and reduces income inequality. Improvements in infrastructure and communication links can:

- increase the potential for mutually beneficial trade between cities, regions or countries;
- facilitate greater interaction between companies, and between companies and their employees, producing an effect similar to them being located more closely together;
- increase employment by increasing the labour market available to a company, and thus ensuring a better match between vacancies and people;
- increase productivity by reducing journey times and improving working and living conditions for people, for example by providing new schools and hospitals;
- enabling effective competition even when companies are geographically dispersed;
- help the economy respond to structural changes, for example by supporting commuter travel and allowing people to access work in growing industries.

Moreover, good standards of infrastructure, e.g. water and sewerage networks or strengthened flood and coastal defences, are essential if any productivity improvements derived from the above are not to be offset by an inability to meet the basic needs of the population.

While the balance of evidence suggests that infrastructure can assist in economic development, research has also acknowledged that a number of other factors need to be in place (Kessides, 1993), such as:

- An economic climate which is otherwise favourable to growth;
- Other inputs must be unconstrained, e.g. availability of skilled labour;
- The new infrastructure must provide the reliability and quality of services in the right places;
- User charges for infrastructure must reflect supply and demand conditions and other factors, such as congestion.

It is also important for the right quantity of new infrastructure to be provided. Too much new infrastructure can draw scarce resources away from repair and maintenance of the existing stock with the result that the economic growth potential may not be maximised (O’Fallon, 2003).

This leads to the critical question of whether England is currently under- or over-supplied with regards to infrastructure. A full assessment of this issue is beyond the scope of this report;

however, there is some evidence to suggest that England is under-supplied with key infrastructure.

- It is estimated by the Department for Transport's National Transport Model that eliminating existing congestion on the road network – relative to free flow conditions – would be worth some £7-8 billion of GDP per annum.
- Over 97 per cent of City of London companies believe that productivity of their staff is reduced by problems faced in commuting (Corporation of London, 2003).
- A study examining expenditure in the London economy identified two key areas for improving productivity: education and skills, and transport infrastructure. It was estimated that an expenditure of £1 million on London's transport system would yield a benefit of around £120 000 per annum through increased productivity (cebr, 2006).
- As reported in the Interim Report by the Barker Review into Land Use Planning, data from the British Chamber of Commerce provide evidence that some businesses are choosing not to expand, or to move out of an area because of transport failures. In addition 76 per cent of businesses report increased operating costs as a result of transport problems (Barker, 2006).

Infrastructure alone cannot create economic growth potential: it can only develop where appropriate conditions already exist. However, it is generally recognised that the provision of infrastructure and economic activity are positively related.

Blackpool and Cleveleys sea defences
Replacement of 100 year old sea wall
Architecturally and aesthetically demanding

Coastal Sea Defences

£62 million investment

65,000 cubic metres of ready mixed concrete and 44,000 cubic metres of precast concrete segments using
>200,000 tonnes of aggregates

Case Study 7 Blackpool Coastal Defence Scheme

Photos: © Tarmac Ltd (used with permission)
Source: Tarmac Ltd www.tarmac.co.uk/concrete/Blackpool.aspx

3.9 SUMMARY OF ECONOMIC CONTRIBUTION

The economic contribution of the aggregates industry extends beyond the direct wealth and employment generated by customers purchasing aggregates. The direct Gross Value Added (GVA) of the industry is just one part of the overall contribution made by aggregates to the English economy. Indirect benefits are also achieved through the interaction between aggregates and other industries (both upstream suppliers and downstream customers), and by their employees spending their wages and salaries.

Table 6 below provides a summary of both the direct and indirect contributions of the industry, together with details of how the indirect contribution is comprised in terms of upstream, employee spend and downstream contributions. For details of how the downstream industries relate to the aggregates industry, please refer to Figure 15. Further details of each of these items have already been described in sections 3.3 to 3.7.

Contribution	**GVA (£ million)**	**Employment (number of jobs)**
Direct	810	8 300
Indirect:		
Upstream (suppliers)	188	4 680
Employee spend	51	1 211
Sub-total	**1 049**	**14 191**
Indirect:		
Downstream (construction products):		
Ready mixed concrete	164	3 977
Coated roadstone	65	370
Mortar	17	280
Concrete products	951	16 837
Sub-total	**1 197**	**21 464**
Indirect:		
Downstream:		
Construction industry	**50 356**	**1 029 983**

Table 6 Summary of economic contribution of the aggregates industry 2005

The gross value added of the English primary aggregates industry is over £1 billion per year. This consists of both the direct contribution of the industry and indirect benefits derived from the industry purchasing goods from its suppliers and employees of the industry demanding goods and services from other parts of the economy.

In addition, downstream industries, such as the manufacturers of ready mixed concrete, coated roadstone, mortar and concrete products, contribute more than another £1 billion to the English economy every year.

The largest benefit derived from the aggregates industry is in providing raw materials to the construction industry which has a gross value added contribution of more than £50 billion per year.

4 Are Significant Imports a Realistic Option?

As mentioned in the introduction to this report, in 2005 the English economy consumed 216.7 million tonnes of aggregates. Seventy per cent of this was primary aggregates extracted from within England or the English continental shelf and 26 per cent came from secondary (e.g. china clay waste) or recycled aggregates (e.g. demolition waste). Only four per cent of the English aggregates requirement was imported from other parts of the UK or from overseas.

This raises the question as to whether it is possible to increase supply from alternative sources, in order to reduce the quantity of land-won primary aggregates extracted in England. A separate report *Aggregate resource alternatives: Options for future aggregate minerals supply in England*, written by the British Geological Survey, with funding from the ALSF, has considered several of the options available (BGS, 2008b). In particular it highlights the locations of current wharves where marine sand and gravel or aggregates imports are landed and discusses the many issues involved in distributing the aggregates from wharves to the market.

This section concentrates on the economic aspects associated with increasing imports from outside England and considers whether there is currently sufficient capacity at English ports to handle the quantity of material that would be required.

4.1 THE SUPPLY CHAIN FOR IMPORTING AGGREGATES

Importing aggregates from overseas requires a supply chain with several elements that all need to fit together if it is to be successful (Figure 21). The following discussion assumes that the imports are brought to England by sea. Imports from Scotland or Wales could, of course, be transported by road or rail (capacity permitting). However, where long distances are involved it is usually more economic to transport aggregates by sea.

Firstly, there needs to be a supplying quarry with sufficient quality, production capacity and reserves to provide the material. The production costs at a quarry outside of England may be higher or lower than those in this country and therefore 'quarry gate' prices may not be similar. The supplying country also has to be willing to export materials to England and there is a greater risk that changing circumstances could suddenly reduce the quantities of aggregates available.

All quarrying has environmental costs, which are discussed further in section 5 of this report, and the same applies whether the supplying quarry is in England or elsewhere. It may be that the location of a quarry in another part of the UK or overseas is more environmentally sensitive than the site it replaces in England, and therefore environmental 'costs' may be higher.

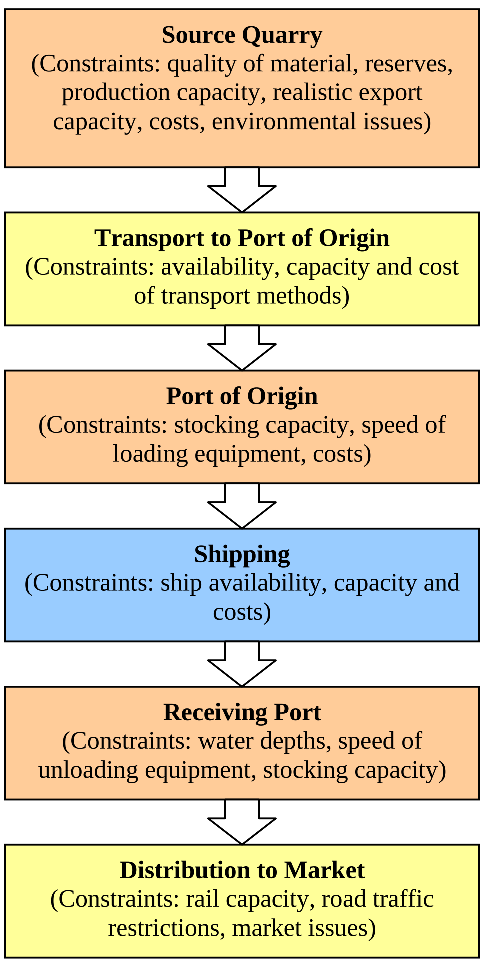


Figure 21 Supply Chain for importing aggregates

Secondly, there needs to be the means of transporting the aggregates from the supplying quarry to the port of origin. In some cases, the quarry could be located alongside deep water, enabling direct loading into large ships. However, this is not always the case and additional transport costs could be incurred.

At the port of origin there needs to be sufficient stocking capacity and there will also be costs associated with loading the material onto ships. For a bulk material, such as aggregates, substantial land areas and equipment will be required and this represents a significant investment. There will also be operational and maintenance expenses associated with this equipment and further environmental costs.

Next there are the economic costs associated with transporting the material by ship and unloading the aggregates at the receiving port. These are considered in section 4.2. Additional environmental costs will also be associated with these activities. Section 4.3 considers the issue of capacity of English ports and whether it is physically possible to import all England's aggregates requirements through existing ports.

Finally, there are the issues associated with distributing the aggregates from the receiving port or wharf to the end-use customers. In some instances, the costs associated with this final distribution could be lower than the distribution costs from quarries in England, if the receiving port is closer to the end market. However, they could also be higher if the distance is greater. Distribution from the receiving port is more complicated for a material such as aggregates than is currently experienced with imports of coal. This is because the imported coal is destined for only a few customer locations (i.e. coal-fired power stations) whereas the aggregates will need to be sent to a wide variety of customers all across the country.

4.2 SHIPPING COSTS AND RECEIVING PORT CHARGES

Shipping costs can be divided into two separate elements: the capital cost of using ships (either purchased or leased) and the operational costs of using these vessels (over and above those included in any lease).

The cost of international vessel hire is currently at an unprecedented high. The price of chartering different sizes of vessel is shown in Table 7. These prices have been converted from US dollars to sterling using an exchange rate of US$2:£1 and are for a one year 'time charter' (whereby the ship owner is responsible for providing the vessel, crew and operating costs while the charterer pays the fuel costs and port charges).

Type of ship	Average 2006, £ per day	Average 2007, £ per day	September 2007, £ per day
Capesize (100 000 dwt+)	22 823	41 695	65 000
Panamax (60 000-100 000 dwt)	11 237	21 870	32 500
Handymax (30 000-60 000 dwt)	10 900	19 042	27 500
Handy (10 000-30 000 dwt)	6 275	10 306	13 750

Table 7 Cost of one year vessel hire

Note: Deadweight Tonne (dwt) is a measure of carrying capacity includes the weight of all cargo, fuel, water, ballast, stores, crew etc., which a seagoing vessel can carry. *Source: Drewry (2007)*

Converting these figures, and the operating costs which follow, into a price per tonne of aggregates requires some assumptions to be made relating to:

- The size of ships that would be used – the analysis was carried out based on Panamax size ships. This represents a compromise between a larger ship being the more economical for bulk transportation and the limited number of deep water ports available to handle these vessels.

- Capacity utilisation – the analysis is based on a deadweight tonnage of 70 000 tonnes, with close to full capacity utilisation which implies a cargo of 65 000 tonnes of aggregates.
- The length of time a typical journey would take – the calculations are based on a typical journey of ten days. This is based on discussions with shipping industry experts who estimate that discharging this quantity of aggregates would take approximately three days and the likelihood that loading, if anything, would be slower. The time at sea is estimated to be two days per leg of the trip (four days for the round trip). This is an estimate of the time taken to sail from a representative quarry in Norway (where it is likely the majority of any imports would be sourced from) to Immingham where an estimate of the port handling costs has been sourced. It is estimated to take three days (each way) to ship aggregates from Glensanda in Scotland to the Isle of Grain in south-east England.

Using these assumptions, the estimates for leasing a ship expressed as a price per tonne of aggregates is shown in Table 8.

Type of ship	Average 2006 vessel hire cost, £/tonne	Average 2007 vessel hire cost, £/tonne	September 2007 vessel hire cost, £/tonne
Panamax, 70 000 dwt	£1.73	£3.36	£5.00

Table 8 Lease costs for vessels per tonne of aggregates (based on 65 000 tonnes of cargo and a 10 day journey)

Source: cebr calculations

It can be seen that the cost estimates vary between £1.75 per tonne and £5.00 per tonne depending on the initial lease cost used. Recognising the expectation that shipping costs will fall from their current peak, a value of close to £3.35 as a base estimate would appear reasonable. Transporting the same volume of aggregates on smaller vessels actually results in a higher cost per tonne because of the increase in the number of ships required.

Clearly, the above costs can be saved if the ship is owned instead of leased, as is sometimes the case. However, ownership of the vessel entails alternative costs, for example depreciation, maintenance and crew. While vessel hire rates are so high there is an additional 'opportunity cost' involved with shipping aggregates because ship owners could potentially earn more by hiring out their ships to transport higher value bulk goods. The current high demand for ships has also caused a delay in available build time for new vessels.

Having chartered a vessel, the key remaining operating cost is that of fuel (known as "bunker cost"). These costs are a function of the type of fuel used, fuel consumption rates at sea and in port, the respective length of time for each of these activities and the cost of fuel.

There are four key grades of fuel used by ships: IFO 180, IFO 380, Marine Diesel Oil (MDO) and Marine Gas Oil (MGO). Typically, IFO 180 or IFO 380 is used when a ship is sailing while MDO and MGO is used more heavily when the ship is in port.

Research suggests that an estimate of fuel used by a Panamax ship would be as follows (Stopford, 1997):

- While at sea – 25 metric tonnes of IFO 380 and 2 metric tonnes of MDO, per day
- While in port – 2 metric tonnes of MDO per day.

Prices for ship fuel are driven mainly by the cost of oil. Indicative costs for these fuels, as of mid December 2007, in Rotterdam were US$435 per tonne for IFO 380 and US$715 per tonne for MDO (Bunker Bulletin Daily, 2007). Although these are spot rate prices and some operators may have been able to secure bunker supplies on long term contracts at prices below the current spot price, these represent a reasonable estimate of current and forward-looking bunker costs.

Combining this information with the estimated voyage time discussed above, and using a two dollar to one pound exchange rate, leads to a total bunker cost estimate of £27 470 and a cost per tonne of aggregates of forty-two pence.

Once the ship arrives at the receiving port additional costs are incurred as port charges. A quotation for these was obtained for landing at the Humber International Terminal at Immingham and this is used to provide an indication of the likely scale of these costs. Clearly there will be some variation between different ports around the country. Port charges consist of two elements: vessel costs (including tug charges, river pilot, mooring charges, etc) and handling costs (good dues, ships dues, crane hire, etc). The estimates obtained are shown in Table 9.

Cost element	Basis of charge	Estimate
Vessel costs	Various	£34 980
Handling costs	£7/tonne	£455 000

Table 9 Port charge estimates

Source: PRB Associates

Combining these two items together results in port charges amounting to approximately £7.54 per tonne of aggregates imported.

In summary, shipping costs and port charges associated with importing 65 000 tonnes of aggregates into Humber International Terminal are estimated to be slightly more than £11.30 per tonne, as shown in Table 10 (although allowance should be made for the number of assumptions included within these figures).

Cost element	Total cost (£) for one journey	Cost per tonne (£) of aggregates
Vessel leasing	218 700	3.36
Bunker costs	27 470	0.42
Port costs	489 980	7.54
Total	**736 150**	**11.32**

Table 10 Overall indicative cost estimate associated with shipping and receiving port charges

Source: cebr calculations

Assuming that a typical 'ex-quarry' price at the originating quarry is the same as in the East Midlands region of England, i.e. approximately £10-12 per tonne for crushed rock or £6-8 per tonne for sand and gravel, the additional cost of shipping and receiving port charges, calculated above, would effectively double the price of aggregates at the landing port.

These calculations do not take into account the following elements mentioned in the previous section:

- Any additional cost for transporting aggregates from the originating quarry to a port;
- Port charges at the originating port; and
- The cost of haulage from the landing port to end use site.

Clearly, there is a very significant additional cost involved in importing aggregates, and this is likely to increase the price charged to customers, such as those in the construction industry.

This analysis also does not take into account the environmental impacts associated with importing bulk materials. Whilst in some elements this 'cost' may be lower, e.g. if the originating quarry is in a less environmentally sensitive area than it would be in England, overall it is likely that the environmental impact would be greater, e.g. due to increased carbon dioxide emissions from haulage. There is also an ethical argument concerning the appearance of 'exporting' environmental impacts to other countries.

4.3 CAPACITY AT ENGLISH PORTS

Aggregates imports would be considered as a "dry bulk" cargo. Comparison can therefore be made between the sales of primary aggregates from within England and the levels of dry bulk activity at English ports. This will provide an indication as to whether it is physically possible to replace indigenous production of aggregates with imports.

Sales of land-won primary aggregates in England since 1972 are shown in Figure 22. Sales figures have been used in this section rather than consumption because it is assumed that any existing imports or exports would continue and it is the requirement for additional port capacity that needs to be examined. Similarly, it is also assumed that marine sand and gravel landings would continue and therefore the figures used are purely land-won extraction.

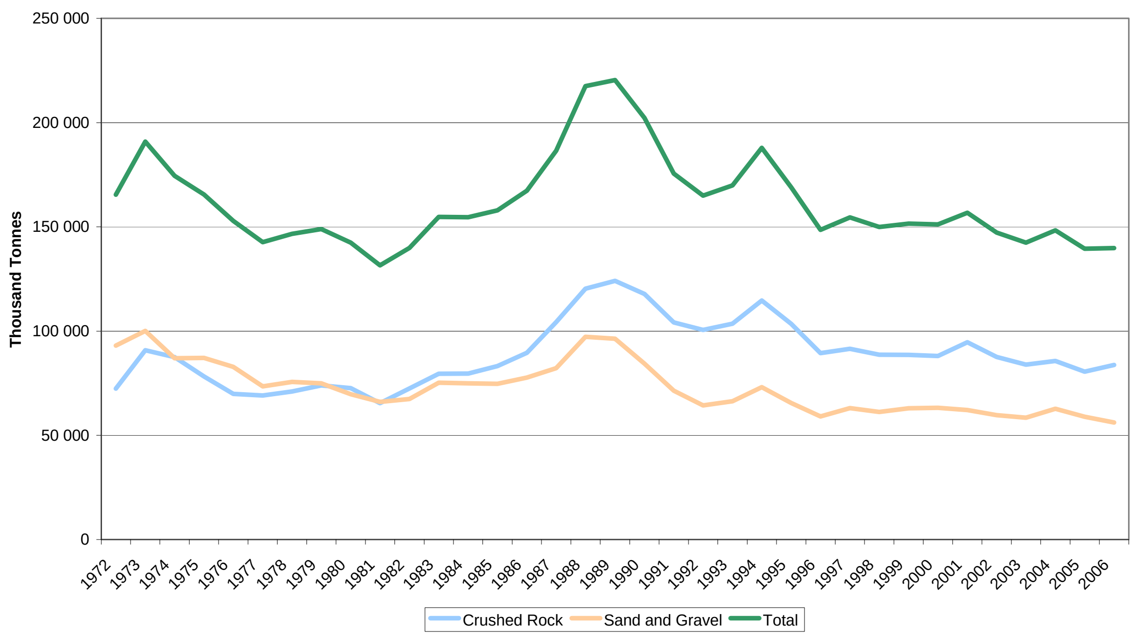


Figure 22 Sales of land-won primary aggregates in England, 1972-2006

Source: ONS (2006a and previous) and British Geological Survey

In the last 10 years sales of land-won primary aggregates have ranged between approximately 139 million tonnes and 157 million tonnes. Port capacity has been examined in light of this requirement range.

Port activity can be divided into four categories: imports (from outside the UK), exports (to countries outside the UK), inward domestic (brought in from other parts of the UK) and outward domestic (taken to other parts of the UK). Dry bulk cargos include coal, iron and other metal ores, agricultural products, animal feed and similar products. Figure 23 compares the tonnage of dry bulk cargo handled in 2006 with the total range of requirements for aggregates in England.

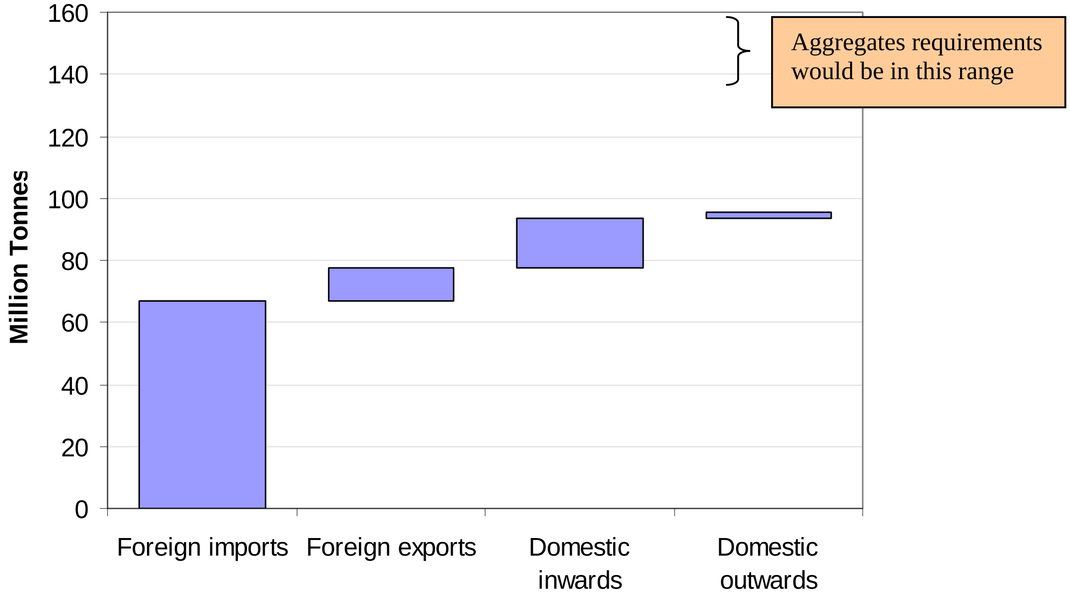


Figure 23 Dry bulk activity at major English ports in 2006 compared to annual primary aggregates requirements

Source: cebr calculations, DfT Maritime Statistics (2007) and British Geological Survey

As shown, the total dry bulk activity at English ports amounted to 95.7 million tonnes, with 66.7 million tonnes imported from outside the UK. This represents between 61 and 69 per cent of the total requirement for primary aggregates in England. The comparison is even starker with current dry bulk material imported into England from outside the UK. England's requirement for aggregates is between 2 and 2.5 times greater than the current tonnage of dry bulk material imported through major English ports.

The picture is not substantially altered by considering the current activity at ports in Wales and Scotland. In 2006 there was an additional 33.5 million tonnes of movements of dry bulk materials in these ports, of which 20.7 million tonnes represented imports from outside the UK. If these figures are included in the total, England's requirement for aggregates is still between 1.5 and 1.8 times higher than the total imports of dry bulk materials through the entire network of Great Britain's ports.

Therefore, if the entirety of England's land-won aggregates requirements were to be replaced by imports, the tonnage of dry bulk materials handled at England's ports would need to at least double. If imports were to replace even a part of the country's aggregates requirement, there would still need to be a significant increase in dry bulk cargoes through these ports. The next question is whether there is sufficient capacity at the major English ports to handle such an increase.

MDS Transmodal (2006) carried out some work for the Department for Transport to provide estimates of traffic levels in dry bulk materials through major ports in Great Britain to 2030. Their forecast is shown on Figure 24. Also shown is the increase in their forecast which would be required if 139 million or 157 million tonnes of aggregates were included.

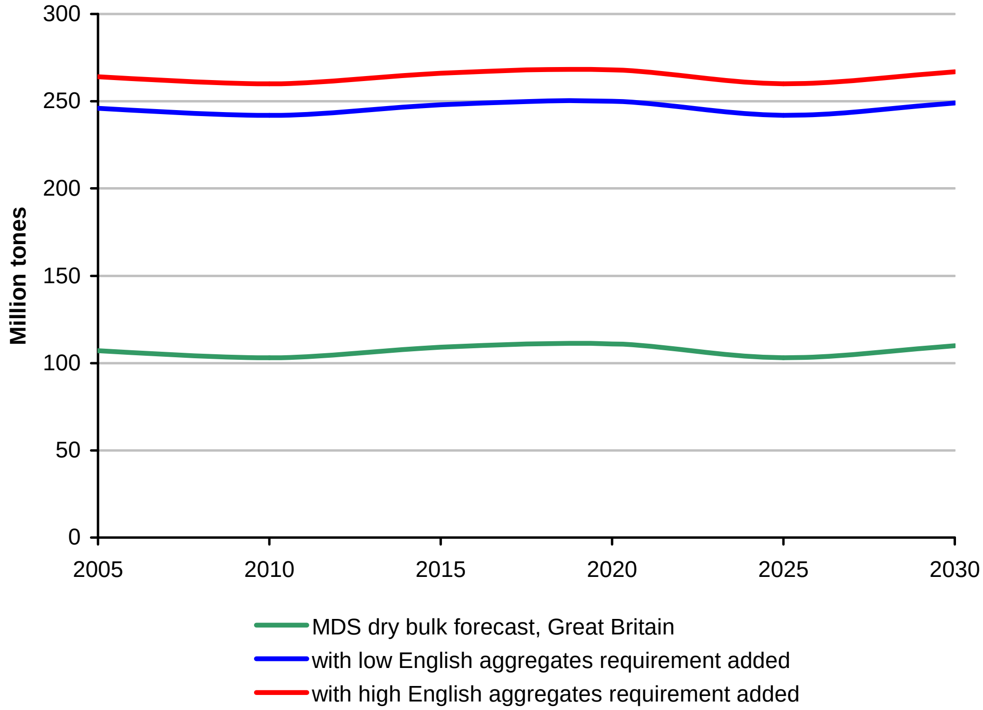


Figure 24 Dry bulk forecasts at Great Britain 'major ports' with and without English aggregates requirement

Source: MDS Transmodal (2006), cebr calculations and British Geological Survey

At the same time as compiling these forecasts, the consultants undertook an initial exercise to examine whether their forecasts were likely to require additional capacity. Their modelling took account of the forecast origin and destination of material flows, likely changes in ship size and the extent to which vessels can substitute from one port to another. Their modelling results suggested that approximately 10 per cent of their forecast traffic level could not be accommodated at current port capacity and consequently concluded that:

> "The results for dry bulk traffic indicate that additional capacity might be required on some deep water estuaries over the next twenty-five years to handle deep-sea traffic, particularly coal imports, that can only be accommodated on a few estuaries."

In other words, at tonnage levels for dry bulk of around 110 million tonnes per year it was considered likely that there would be capacity constraints at key port infrastructure sites. Clearly, adding a significant amount of England's aggregates requirement of between 139 to 157 million tonnes would substantially exacerbate these constraints.

A recent update of this work by MDS Transmodal (2007) has not significantly altered these forecasts and therefore do not alter the underlying conclusions.

The recent Humber International Terminal Phase 2 project at Immingham provided an additional 9.5 million tonnes of capacity at a capital cost of £59.5 million. This is an indication of the costs involved in increasing port capacity. Although a crude estimation, scaling up these figures give an approximate cost of £940 million to increase dry bulk port capacity by 150 million tonnes.

However, it is by no means certain that such a substantial increase in port capacity is possible due to other limiting factors such as water depths in England's estuaries and availability of land. Geography plays an important part in this issue. Some regions of the country already have more port facilities than others as a result of the number and size of estuaries in that region and therefore the potential to increase port capacity varies across the country. It may be that the areas with the greatest potential for extensions to ports are also the furthest away from the main centres of demand. As a consequence the feasibility of port expansion for the purpose of importing aggregates is complex and the costs involved may be higher than anticipated.

Even if capacity were to be increased it is likely that higher value industries, such as those importing metal ores or coal, and non-dry cargoes such as liquefied natural gas (LNG), would successfully negotiate for space in these new facilities and lower value commodities, such as aggregates, would find it difficult to compete.

Importing a substantial tonnage of aggregates into England has implications other than cost and port capacity constraints. There would also be a substantial impact on the rail and road infrastructure and emissions of carbon dioxide are likely to increase significantly.

In addition, there are implications for the supply capacity of ships. Based on the journey time and ship capacity used previously, one Panamax ship would be able to import a maximum of 2.3 million tonnes per year, assuming no additional time was lost due to maintenance of the vessel. To import the entirety of England's requirement for aggregates would therefore require approximately 65 Panamax ships (or larger numbers of smaller vessels). In the current situation where ships are in high demand it is doubtful whether such large numbers of ships would be available.

These results also reflect a significant difference between aggregates and many other imported dry bulk materials notably coal: while coal imports need only travel to a small number of power stations, the destination for final uses of aggregates are far more dispersed around the country. This necessarily increases the road and rail haulage distances associated with any imported material.

Finally, the analysis has effectively assumed that were England to source all of its material from overseas it could do this without any impact on supply in other countries. Effectively the assumption is that England is a sufficiently small country in the world market that European/world supply could effectively respond to any change in England's import demand without those fluctuations impacting on price.

The preliminary evidence collected on this issue suggested a divergence of views on this point. Discussions with representatives from the Norwegian Geological Survey suggested there were sufficient resources available from Norway to meet a substantial English import requirement. However the geological quality of these resources has not been fully established nor compared with the resources in the UK. Representatives from the aggregates industry were more sceptical of whether the private sector would be prepared to undertake the investment needed to provide such resources. A concern was expressed that if a significant bulk of any material extracted only went to England, and was therefore uniquely exposed to fluctuations in the English market, this may make the associated risks too high to justify the investment although recent investments have been made in Norway in order to supply the wider European market. This also raises the issue of whether demand for aggregates in England could compete for Norwegian material with the demand from other European countries.

Importing the entirety, or even a substantial proportion, of England's aggregates requirements is not physically possible at current port capacity. Increasing capacity at England's ports is expensive and it is not feasible to increase it sufficiently to meet all, or a significant part of, the country's need for aggregates.

5 Environmental Effects of the Aggregates Industry

The previous sections have outlined the economic benefits brought to the English economy by the aggregates industry, but it is also important to recognise there are environmental benefits too. Many biological and geological SSSIs are associated with quarries in England and the restoration of former extraction sites regularly contribute to the country meeting its Biological Action Plan (BAP) targets. Other quarries are restored to high class sporting and leisure facilities, such as the National Rowing Centre at Holme Pierrepoint.

However, it should be recognised that the industry does result in some environmental costs. These costs can be divided into two categories:

- Amenity value – The general deterioration in ‘amenity value’ caused by extraction and transport of a bulk mineral, such as aggregates, which includes noise, air pollution, traffic congestion, etc.
- Carbon dioxide emissions caused by quarrying itself and by the transportation of aggregates from the quarry to the point of consumption.

To easily compare these costs with the economic benefits identified in section 3, an attempt needs to be made to attach a monetised value to them. There are a number of different approaches to do this as outlined in the following section.

London 2012 Olympic Park

80,000 seat stadium
aquatics centre
velopark
other sporting venues
Olympic village
media centre

Full details of aggregates and concrete requirements are not yet known, but a recent tender invitation was issued to supply
600,000 cubic metres of Aggregates
For road bases, drainage, fill and block paving

Concrete requirements are expected to reach 1,000 cubic metres per day at peak construction, using
2,000 tonnes of Aggregates per day

Case Study 8 The London 2012 Olympic Park

Photos: © London 2012 (used with permission)
Source: London 2012 official website www.london2012.com

5.1 VALUING THE ENVIRONMENT: DIFFERENT APPROACHES

Attempting to place a value on the environment, and hence on the 'consumption' of the environment, is difficult because it is not something which is traded. The value of a traded good can be ascertained by how much people are prepared to pay for an additional amount. However, this does not apply to the environment and therefore different approaches are needed.

Firstly, it is necessary to determine what is meant by the word "value" in the context of the environment. This could be:

- **Use Value** – the value associated with using the environment, e.g. visiting a park or intending to visit a park; and/or
- **Non-use Value** – the value associated with the well-being of future generations (bequest value), the satisfaction gained from another individual's enjoyment (altruistic value), or the value attached to knowing something exists (existence value).

Five different methods of attempting to derive valuation estimates are described briefly below, with further details provided in Appendix 5.

5.1.1 Contingent valuation (CV)

Contingent valuation, at its simplest, asks people to place a value on how much they would be prepared to pay in order for something to be supplied (known as their 'willingness to pay'). This approach has been applied the most widely for valuing the environment. The most significant benefit of CV is that it can provide accurate estimates of the values placed on aspects of the environment, providing stringent guidelines are followed. It is also very flexible and can be adapted to estimate the economic value of almost anything.

However, CV does have its disadvantages. The primary criticism is that values given in CV surveys are not based on real commitments and therefore when asked what they would be willing to pay a person may give an unrealistically high response. For example, a person may express a willingness to pay a high figure knowing full well that they will never have to actually pay out the sum mentioned. This is known as the 'warm glow' effect.

Secondly, people may express different willingness to pay depending upon how that 'payment' would theoretically be made. For example, asking how much extra tax they would be prepared to pay is likely to result in a lower answer than if asked how much donation someone would be prepared to give. In addition, the results of CV can be biased by the depth of knowledge of the survey recipients and the way information is presented to them. CV surveys can be very expensive and time-consuming to conduct and the results can be difficult to validate.

5.1.2 Hedonic pricing

This method entails assessing environmental values based on observing the behaviour of actual market transactions. For example, a study to assess the impact of air pollution on house prices could be undertaken by analysing the difference in house prices for similar houses within a polluted and unpolluted area. As the houses are similar, the different in price between them can be seen as reflecting the residents 'willingness to pay' for lower levels of pollution.

Hedonic price studies must control all other factors that could affect the price of the item, therefore, in the example above, the two houses must be identical in terms of size and quality, and the neighbourhoods must be similar in terms of amenities, crime rates, infrastructure, etc. The major disadvantage of this method is that it can only be used where the non-market good concerned (e.g. air pollution) has an impact on a market good (e.g. house prices). However, there are several environmental problems which do not affect any market good where this method is ineffective, such as the loss of a species of plant or animal.

The hedonic price method also suffers from the assumption that the problem being valued (e.g. air pollution) is reflected fully in the price of the market good, which may not always be the case. However, this method does have the advantage of being based on real market decisions rather than perceptions.

5.1.3 Defensive expenditure

This method seeks to estimate a person's 'willingness to pay' to remove or reduce a negative environmental impact. For example, if a person is impacted by the noise, the amount they are prepared to pay for sound proofing their home can be used as a monetary estimate of the impact. However, this method can only be used for negative environmental impacts. For positively valued environmental goods, such as National Parks, it could be possible to measure the amount of travel expenditure incurred to visit the park, but this can only be thought of as a minimum 'willingness to pay' because the person may have been prepared to pay more but did not have to.

5.1.4 Experimental markets

This method is similar to CV except that it involves the actual exchange of money for a real 'good'. The disadvantage is that it is more difficult to turn a hypothetical situation, such as the loss of a rainforest, into a real scenario which the respondent will take seriously.

5.1.5 Voter referendum

This method assumes that the individuals who place the highest value on a particular environmental 'good' are most likely to vote in favour of it. Different increases in taxation can then be specified and observations made of how people vote.

This overcomes some of the shortfalls in the CV method because the environmental good in question is real and the decisions made are binding. Voters can be well informed of the arguments during pre-election campaigning. However, balloting is confidential which can make it difficult to explain the final outcome. In most cases they are also impractical and expensive.

5.2 CONTINGENT VALUATION OF AGGREGATES EXTRACTION IN THE UK: PREVIOUS WORK

The most extensive research project aimed at deriving estimates on the environmental cost of aggregates extraction in the UK, in terms of amenity value reduction, was a study conducted by London Economics (1999) to inform the debate on the Aggregates Levy.

This study concluded that for areas outside a National Park people would be willing to pay £0.34 per tonne for hard rock extraction to cease and £1.96 per tonne for sand and gravel extraction to cease in their local area,. Within a National Park their willingness to pay increased to £10.52-£10.80 per tonne.

The London Economics study was controversial for a number of reasons. Some people objected to the principle of trying to place a monetary value on environmental cost. Others were concerned that the study did not give account to the many environmental benefits associated with aggregates extraction, specifically in terms of the restoration of land after extraction has been completed (see Appendix 5 for further details).

5.3 ESTIMATED AMENITY VALUE REDUCTION CAUSED BY AGGREGATES EXTRACTION IN ENGLAND

In the absence of better data, and recognising the difficulties with the whole approach, the willingness to pay estimates derived in the London Economics study are considered to be the best estimates available. However, it should be noted that these estimates were derived in 1999 and changes since then require these figures to be updated.

In particular income levels have risen between 1999 and 2007. For most goods (known as 'normal goods') when income levels increase the demand for them also increases. However, there are some cases where higher income leads to lower demand (known as 'inferior goods'). Therefore in order to update the values obtained in 1999, it is important first to determine whether environmental 'goods' can be considered as 'normal goods', i.e. will the willingness to pay increase as income levels increase. Secondly, it is necessary to determine whether any increase in willingness to pay is proportionate to the level of increase in income. Various studies have been conducted into this subject (as indicated in Appendix 5) and these suggest that there is some variation at different income levels.

In order to provide an updated estimation of the amenity value reduction associated with aggregates extraction, the following aspects were taken into account:

- The willingness to pay values were updated to 2005 prices
- The change to English household disposable income from 1999 to 2005
- The change in extraction levels from 1999 to 2005
- The variation in how willingness to pay increases as income increases

Figure 25 shows that there has been an increase in the estimates of the environmental cost (due to amenity value reduction) of the aggregates industry between 2001 and 2005. The 2001 estimates range between approximately £325 million and £370 million (in 2005 prices) while by 2005 these estimates have increased to between £365 million and £410 million. The largest increase is between 2003 and 2004 when both the tonnage extracted and income levels increased significantly.

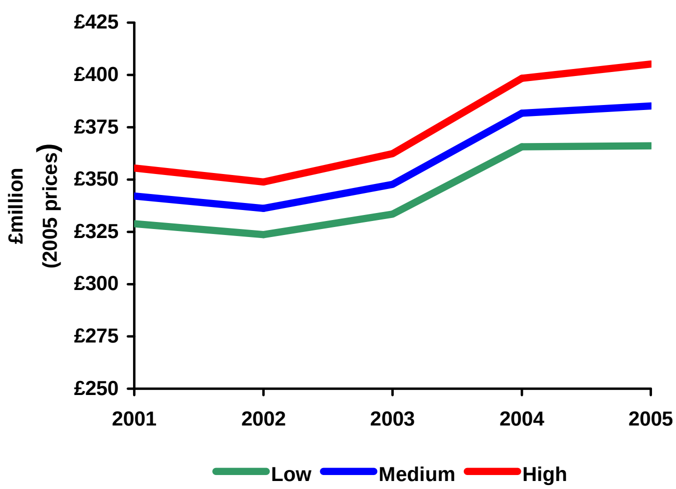


Figure 25 Estimates of the amenity reduction caused by aggregates extraction in England

Source: London Economics(1999), The Office of National Statistics and cebr analysis

5.4 THE CARBON DIOXIDE EMISSIONS FROM AGGREGATES EXTRACTION AND TRANSPORTATION

Extracting aggregates and processing the raw material into saleable products requires energy to power both mobile machinery (such as excavators and haul trucks) and fixed equipment (such as conveyor belts, crushing machines and screens). Similarly transporting the finished aggregates products to the end-use customers requires additional energy, whether that transport is conducted by road, rail or sea.

The British Geological Survey has been conducting research into the carbon emissions of the minerals industries and the aggregates industry themselves are starting to develop policies and plans to reduce their 'carbon footprint' (QPA, 2007). However, accurate estimates of total carbon dioxide emissions remain difficult to obtain and various assumptions have to be included to allow for incomplete data availability.

It is estimated that land-won primary aggregates extraction and transport in England accounted for just under 1 220 000 tonnes of carbon dioxide emissions in 2005. This figure includes the imports of crushed rock from Scotland. In addition, the landing of marine sand and gravel in England emitted a further 140 000 tonnes of carbon dioxide. This can be compared to carbon dioxide emissions for the UK as a whole of 554 200 000 tonnes in 2005 (DEFRA, 2007a).

At the time of writing, the European Union's Emissions Trading Scheme has a price of around €22 per tonne of carbon dioxide emitted (EU, 2008), which equates to approximately £16 per tonne. However, other work by the Department for Environment, Food and Rural Affairs suggests that the 'social cost of carbon dioxide' is in the range of £23.30 to £25.50 per tonne emitted (DEFRA, 2007b). The 'cost' of the carbon dioxide emissions for primary aggregates in England is therefore estimated to be in the range of £21.8 million and £34.7 million per year.

It should be remembered, however, that these figures represent only a broad estimation of the likely cost for carbon dioxide emissions and many assumptions have been used in their compilation. As more detailed studies are conducted in this area it is expected that more precise and more accurate figures will be forthcoming.

108 kilometres of high speed railway line
152 bridges, 1.2 kilometre viaduct over River Medway
26 kilometres of tunnels

Channel Tunnel Rail Link

Refurbished St Pancras station

New stations at Stratford and Ebbsfleet

£5.2 billion investment

More than 1,000,000 cubic metres of concrete, using 2,000,000 tonnes of aggregates

Additional aggregates were also used as rail ballast to keep the railway track in place and support the weight of the trains.

Case Study 9 Channel Tunnel Rail Link

Photos: St Pancras: S Hannis BGS © NERC, Medway viaduct: © London and Continental Railways (used with permission)

Sources: Department for Transport website www.dft.gov.uk and St Pancras station website www.stpancras.com

6 Conclusions

There is a demand for aggregates that needs to be met in the interests of the economy and society.

- In England 216.7 million tonnes of aggregates are consumed each year.
- This is used to build houses, hospitals, schools, and many other infrastructure projects. Large quantities are required for high profile construction projects such as the Olympic Park, the new Wembley stadium and Terminal 5 at London Heathrow Airport.
- The Government's objectives for affordable housing, Sustainable Communities and major regeneration projects, such as the Thames Gateway, will all require significant quantities of aggregates.
- Similarly aggregates are required for climate change adaptation (e.g. flood defences) and mitigation (e.g. renewable energy programmes and nuclear power stations).

The industry brings considerable economic benefits to the English economy.

- The gross value added of the English primary aggregates industry is over £1 billion per year. This consists of both the direct contribution of the industry and indirect benefits derived from the industry purchasing goods from its suppliers and employees of the industry demanding goods and services from other parts of the economy.
- Downstream industries, such as the manufacturers of ready mixed concrete, coated roadstone, mortar and concrete products, contribute more than another £1 billion to the English economy every year. These industries could not exist without aggregates.
- The largest benefit derived from the aggregates industry is in providing raw materials to the construction industry which has a gross value added contribution of more than £50 billion per year. Aggregates are an essential raw material for the construction industry.
- The aggregates industry directly employs 8300 people with an additional 21464 people employed in the construction products industries (coated roadstone, ready mixed concrete, mortar and concrete products).
- The construction industry is a major employer in the English economy, providing jobs for more than one million people (approximately 4.5 per cent of the total English workforce).

Significant imports of aggregates are not a realistic option.

- The additional cost per tonne that would be incurred by importing large quantities of aggregates is likely to be substantial. This would have an adverse impact on downstream customers including the construction industry.
- Importing the entirety, or a substantial proportion, of England's aggregates requirements is not physically possible at current port capacity.
- England's land-won primary aggregates requirement is more than twice the 95.7 million tonnes of dry bulk cargoes currently imported through English ports. Capacity increases are already required to meet a forecasted increase in dry bulk cargoes.
- Increasing capacity at England's ports is expensive and it is not feasible to increase it sufficiently to meet all, or a significant part of, the country's need for aggregates

- A recent expansion at the Humber International Terminal, costing £59.5 million, increased capacity at the port by only 9.5 million tonnes of dry bulk cargo.

The environmental 'cost' of having an indigenous aggregates industry is much less than the economic benefits the industry brings to the English economy.

- It is estimated that the cost of amenity value reduction can be quantified as between £365 million and £410 million per year.
- This study estimates that the costs of carbon dioxide emissions are probably in the range of £21.8 million and £34.7 million per annum.
- The direct contribution of the indigenous aggregates industry to the English economy is £810 million and this is greater than the estimated environmental 'costs', even before taking the additional indirect contributions into account.

The economic growth of the country is linked to the quality of infrastructure. The construction industry is an essential component of this infrastructure provision. Aggregates are a vital raw material for this industry. An adequate and reliable supply of aggregates is therefore essential for economic growth in England.

The volumes of aggregates required each year make it impossible to import the entirety of the England's requirements. Substantial investment will be required to increase port capacity if aggregates are to be imported in larger quantities than present. Secondary and recycled aggregates are approaching the maximum available. There will continue to be a need to meet demand for aggregates and this will have to be provided mainly from indigenous sources for the foreseeable future.

Appendix 1

USING OFFICIAL STATISTICS

All economic data, where possible, has been taken from official Office of National Statistics (ONS) data and statistics. The main source of information was from the *Annual Business Inquiry*. Information from the *Annual Business Inquiry* is available from both the Office of National Statistics website and Nomis *Official Labour Market Statistics*.

All data is in 2005 prices, the Gross Domestic Product deflator was used at market prices to bring all prices inline.

Defining the aggregates sector

To classify the 'aggregates sector' the standard industrial classifications (SIC) were used. In particular, the following sections:

14. Other mining and quarrying

14.21 Operation of gravel and sand pits

This section also includes 'crushed stone of a kind used for concrete aggregates, for roadstone and for other construction use'. The guidance notes for the ONS state that the 4 digit SIC codes are the same as the first 4 digits in another coding system called PRODCOM (which is a standardised system used across the European Union). The ONS produce reports, based on PRODCOM codes, called *Product Sales and Trade*. Assuming the values shown against SIC codes are the same as those shown in these reports against PRODCOM codes, these were used to work out what proportion of the SIC codes are 'in scope' for the definition of the aggregates sector. Specifically 'silica sands', 'slag for construction use' and 'coated roadstone (tarred macadam)' were removed from the above code when calculating the direct impact of the aggregates sector.

The proportion of the Great Britain sales volume of aggregates attributable to England, obtained from the ONS Business Monitor PA1007 *Mineral Extraction in Great Britain*, was used to calculate the proportion of value that can be attributed to England aggregates.

Regional calculations

From Nomis regional employment data for four digit SIC sectors was obtained. This was used, together with the proportions discussed above, to calculate employment in the aggregates sector on a regional basis.

Regional GVA from the Office of National Statistics was specifically requested. Where this information was available it was used in the same way as regional employment data. Where data was not available, employment data was used to proportion the United Kingdom total GVA and turnover between regions.

Upstream GVA, turnover and spend

A model was built to calculate the upstream GVA, turnover and spend. This model used the Office of National Statistics '*Input-Output tables*'. These tables are available for the years 1999 to 2005. They are a matrix detailing the amount of goods and services each sector provides each other sector in the United Kingdom. Using the links to other sectors the support an industry provides a sector can be determined — the upstream effect. This is calculated in terms of gross value add, turnover and spend. A similar technique was used to determine employee spend but taking into account the mean gross annual pay for all employee jobs in each sector.

Where GVA and turnover sector data is missing for smaller sectors the model uses employment data to find how the larger sector should be broken into the smaller sectors. The model also includes a 'mapping' to make the input output categories consistent with our SIC codes, and therefore our aggregates sector definition.

Downstream calculations — the construction sector

A similar methodology was used to calculate the value of the construction sector. In particular, input-output tables were used for the United Kingdom's spend on the construction sector. As the construction sector is much larger than the aggregates sector 'in-scope' definitions or regional information were not needed.

Other Downstream sectors

The following SIC and PRODCOM codes were used:

26.63 Ready mixed concrete

26.64 Mortars

26.61 Concrete products for construction purposes

Part of 14.21 for Coated roadstone (tarred macadam)

Appendix 2

THE SENSITIVITY OF CONSTRUCTION ACTIVITY TO AGGREGATES PRICES

An econometric model was developed which attempted to explain (changes in) Great Britain new non-housing construction output[1] as recorded by Department for Business Enterprise and Regulatory Reform (DBERR)[2] according to changes in three key factors:

- construction costs, as proxied by the DBERR resource cost index of building non-housing[3]. We used this general index rather than a specific aggregates price index as it provides a richer data set. We also considered that given the various inputs needed for the construction sector, e.g. timber, glass, labour a generic index such as this was more likely to capture the output dynamics of the industry
- UK GDP as a proxy for demand in the industry
- the Bank of England base rate

The precise form of econometric technique used was an ‘error correction mechanism’ model. The advantage of this technique was that it allowed account to be taken of the significant lags that exist between changes in these explanatory variables and construction activity to be developed. Consequently, it was possible to estimate both the short run and long run elasticity of construction activity with respect to aggregates prices. The short run elasticity measures the effect that a particular factor has on construction activity in the following quarter; the long run assesses the impact when all lagged effects and responses have worked through.

One way to test the validity of the model in explaining changes in construction output, and hence the credibility of any elasticity estimates derived from the model, is to compare the change in construction output, from the previous quarter, predicted by the model (for the given set of explanatory factors) with the actual change in construction output from the previous quarter. This is shown in the figure below.

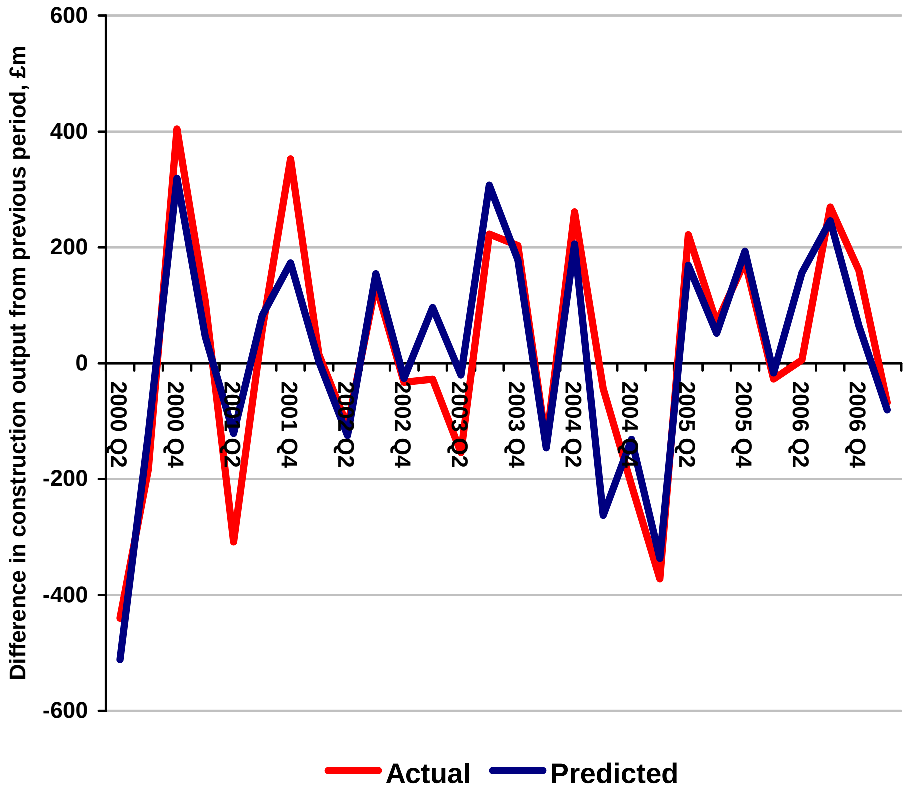
This figure shows that the explanatory power of the econometric model is relatively strong. Associated statistical tests suggested that 82.2per cent of the variation in the changes in construction activity that explained by the model. This suggests that reasonable confidence can be attached to the elasticity estimates that have been derived using the model outputs. On the other hand, only limited data is available to undertake the modelling: this implies a degree of caution should be attached to the results.

---

[1] This excludes housing and repairs and maintenance output but includes infrastructure output. Housing output is considered separately using a different technique to reflect the greater similarity in the output produced in this sub-sector of the construction industry.

[2] Great Britain’s construction output was used due to the ease of obtaining data. Although the primary focus of this report is on English aggregates (and construction) it is not considered that the use of Great Britain data for this exercise is problematic: it can be assumed that the relationship between aggregates prices and construction output does not differ significantly between England and the rest of Great Britain. The dataset used also defined output differently from the approach taken by the Office of National Statistics to defining GVA.

[3] DBERR (2007) Construction Statistics Annual 2007, Table 5.1, August



Source: cebr calculations

An Error Correction Model in which both the short- and long-run parameters were estimated simultaneously was undertaken. The general form of the ECMs were specified according to Equation 1, with all variables expressed in natural logarithms:

$$\Delta Q = \sum_i \beta_{qi} Q_{t-i} + \beta_1 \Delta conco + \beta_2 \Delta GDP + \beta_3 \Delta ir + \begin{array}{l} \sum_i \beta_{concoi} conco_{t-i} + \sum_i \beta_{GDPi} GDP_{t-i} + \sum_i \beta_{iri} ir_{t-i} \\ + s_1 + s_2 + s_3 + \upsilon \end{array}$$

where:

ΔQ is the change in non-housing construction output in constant prices between that quarter and the previous quarter

Q_{t-i} is the value of non-housing construction output in various previous quarters

$\Delta conco$ is the change in the resource cost index for non-housing construction output

ΔGDP is the change in GDP between one quarter and the previous quarter

Δir is the change in the Bank of England base rate between one quarter and the previous

$conco_{t-i}$ is the value taken by the resource cost index for non-housing construction output in previous quarters

GDP_{t-i} is GDP in various previous quarters

ir_{t-i} is the Bank of England base rate in various previous quarters; and

$s_{1,2,3}$ are seasonal dummies; and

υ is a random error term

In order to determine the lag structure to be included in the regression equation, the partial auto-correlation function (PACF) for each of the variables was calculated. This is an econometric tool which measures the extent to which the value a variable takes in one period is correlated with (linked with) the value taken by the same variable, say, two periods ago. Critically, the partial autocorrelation function adjusts for the 'linkage effect' whereby the value taken by the variable two periods ago could also impact on the value taken by the variable one period ago which will impact on the value taken by the variable today.

By removing the impact of intervening variables, the PACF identifies those lags which are most likely to be of interest. It is assumed that the current values of the variables influence construction output. Beyond this, if the PACF indicates that there is little or no relationship between the current value taken by that variable and previous values then it is unlikely to be important in explaining changes in construction output. By contrast, if there is a strong positive or inverse relationship between the values taken by the variable in previous months then it is more likely to be included in the model.

PACFs were constructed for each of the three explanatory variables. However, due to a lack of data, lags of only up to ten quarters (i.e. two and a half years) were considered to be candidates for inclusion in the model.

The PACFs indicated that lags one and seven should be included for the output variable; one, four, six, seven, eight and nine should be included for the cost variable; one, nine and ten should be included for GDP; and one, two and four should be included for interest rates.

With the initial lag structure of the model developed, the initial econometric model was developed. A standard general-to-specific approach was then adopted to exclude all variables that the model suggested were insignificant at 95 per cent confidence (i.e. only those variables which had coefficient estimates that we could be 95 per cent confident did not have a value equal to zero were included in the model).

The econometric model so developed could then be used to estimate the elasticities. The short run elasticities were simply the parameter estimates on the change in the variable between that quarter and the previous quarter. The long run elasticities were calculated, for each variable, as the sum of the coefficient estimates on the significant lags of the explanatory value, divided by the absolute sum of the parameter estimates for the significant lags for construction output. For instance, the long run elasticity of construction output with respect to the price of aggregates is calculated as:

$$\varepsilon_{\text{aggpLR}} = \frac{\sum_i \beta_{aggp}}{\left|\sum_i \beta_q\right|}$$

Appendix 3

THE IMPACT OF INCREASING AGGREGATES PRICES ON THE CONSTRUCTION OF HOUSES

The essence of the model is that it assumes that the market is not perfectly competitive (in which case the price of a new home would be equal to the marginal cost of its construction) but, rather, oligopolistic i.e. there are a relatively small number of 'large' firms. It then makes use of the Cournot oligopoly framework; which represents the 'standard' approach to considering oligopolistic markets.

The key inputs that have been used for the modelling are the following:

- The marginal cost of building a new home is assumed to be £150 000, taking account of the finding from the Interim Report of the Barker Review that approximately 85 per cent of housebuilders' costs are variable.[4]
- The price elasticity of demand for a new home (ie the percentage demand for new homes will decrease in response to a one per cent increase in their prices) was taken as 0.5, sourced from academic papers.[5]
- In the base case, it is assumed that the typical cost of a tonne of delivered aggregates is £12 per tonne and that to build a new house, 300 tonnes of aggregates are required; approximately 60 tonnes for the construction of the actual house and 240 tonnes (per house) for the access roads required on each new development.

Using these assumptions, the model predicts a market outcome prior to the cost shock not too dissimilar from current actual market values. Specifically, the model predicts that the average price of a new house of £182 839 and the gross number of completions per annum of 198 541. These compare with actual figures for price (at the time of writing) of approximately £214 198[6] and completions of approximately 185 000.[7] The fact that the model predicts, in equilibrium, lower prices and a higher number of completions than found in the market is consistent with the view that there are a range of factors which prevent the supply-side of the housing market responding as dynamically as might otherwise be expected.

Due to the assumptions imposed by the modelling approach, the total market output is assumed to be shared equally across fourteen equally-sized firms.

The market for the construction of new homes is then 'shocked' by a restriction in the supply of aggregates, causing the price of aggregates to rise. The model is run to see what happens to the average price and estimated number of completions. All firms in the market are assumed to be affected by the cost shock. Two factors affect the market outcomes:

- The size of the price shock for aggregates
- The intensity of aggregates used in building a house (due to a lack of data, no attempt is made to consider how intensity of use of aggregates may decline in response to an increase in their price)

[4] Barker, K. (2003) Barker Review of Housing Supply: Securing our future housing needs, Interim Report, Footnote 22,
[5] Cameron, G., Muellbauer, J. and Murphy, A. (2006) Was there a British House Price Bubble? Evidence from a regional panel, July. Available at: http://hicks.nuff.ox.ac.uk/users/cameron/papers/wasthere.pdf
[6]http://www.houseladder.co.uk/Property_News/2006/10/Average_new_home_prices_fall__per_cent_290.aspx
[7] DCLG (2007) *op. cit.*

Cournot modelling

The market modelling exercise uses a Cournot framework to consider an impact of a cost shock on the market for the building of new homes. In undertaking this analysis, a number of assumptions are made about the behaviour of firms in the marketplace and the nature of competition. The key assumptions are the following:

- firms aim to maximise profits;
- the 'strategic variable' chosen by companies is the amount of new homes that they construct, rather than price that they set for the homes (firms can only ever choose one of price or quantity, the other determined by the demand curve);
- the market for the construction of new homes is a national market which would imply, *inter alia*, that the price for new homes is the same across the country with no regional differences;
- the output that firms produce is homogeneous;
- firms have a cost structure which consists of a fixed costs incurred by all firms in the market and a constant marginal cost for each home built;
- the model assumes that all firms have the same constant marginal cost.
- there is a constant, linear relationship between demand and price.

Some of these assumptions used in the theoretical framework are more difficult to justify in the context of the United Kingdom's housing market than others. Of these, arguably the most difficult two assumptions are those of the assumption of a national market and hence no regional variation in price, and that the output produced by home constructors is homogenous. However, in terms of the first assumption, policy decisions and made, and data is most frequently available, on a national basis. In terms of the latter, we have used average or typical figures where necessary.

Given this, however, the modelling results should be seen as stylised representations of the likely 'typical' impact on the market(s) for new homes of a cost shock in the upstream price for aggregates.

With these assumptions made, the mathematical underpinnings of the model are as follows.

The relationship between price and output (Q) is given by the following, downward sloping demand curve:

$P(Q) = a - bQ$ Equation 1

The cost curve for each firm i (i=1…n) is given as:

$C_i = F_i + c_i q_i$ Equation 2

Firm's profits, $\prod_i$ are given by the product of the number of houses they sell and the price they sell them at, less the cost of production.

Using equation 1, and noting that $Q = \sum_i^n q_i$ this can be seen as being:

$\prod_i = q_i P(Q) - (c_i q_i + F_i)$ Equation 3

Assuming that firm's choose quantities to maximise profits, this profit function can be differentiated with respect to q_i to yield the profit maximising condition of:

$P(Q) - c_i - bq_i = 0$ Equation 4

All firms have the same profit maximising condition, so it is also the case that:

$$NP(Q) - \sum_{i=1}^{n} c_i - bQ = 0 \qquad \text{Equation 5}$$

Dividing by N, letting c* be the average of all marginal costs, i.e.

$$c^* = \left(\sum_{i=1}^{n} c_i\right)/N$$

and rearranging gives:

$$P(Q) - (bQ)/N = c^* \qquad \text{Equation 6}$$

Substituting equation 1 into equation 6 and rearranging gives:

$$Q = \frac{\left(N/N+1\right)(a - c^*)}{b} \qquad \text{Equation 7}$$

Substituting this back into equation 1 and re-arranging gives:

$$P = \left(\frac{1}{n+1}\right)a + \left(\frac{n}{n+1}\right)c^* \qquad \text{Equation 8}$$

Appendix 4

THE LINK BETWEEN INFRASTRUCTURE INVESTMENT AND ECONOMIC GROWTH

The link between infrastructure investment and economic growth in developed countries is complex. When it comes to its quantification, a number of questions persistently arise. Indeed, while there is a large consensus on the existence of a definite link between those two variables, concerns remain over the direction of the causality, its importance and the different channels it employs.

The seminal work on the link between productivity/economic growth and infrastructure essentially was provided by David Aschauer[8]. Aschauer found that the output elasticity of public investment in infrastructure was 0.24. In other words, a one per cent increase in investment in public infrastructure would lead to a 0.24 per cent increase in the output of the private sector. This led him to argue that the decline in productivity growth during the 1970's in the United States of America was largely due to a decline in public investment in infrastructure.

However, as research in the field progressed, disputes over the direction of causality between changes in productivity and investment in infrastructure arose i.e. did infrastructure cause economic growth or did economic growth lead to increases in infrastructure? Evans and Karras (1994)[9] found strong correlations between the two variables on a panel of seven OECD countries, but concluded that the direction of causality was in the opposite direction. Button also argued that early studies, such as Aschauer's several papers, used relatively simplistic econometric techniques to study the productivity effect of infrastructure, which later, more suitable, econometric techniques proved to be spurious[10].

Since then, progress has been made on the back of stronger econometric theory. Although it still represents an area of some contention, the balance of evidence suggests that the causality is in terms of more infrastructure leading to higher economic growth. In 2000, based on his cross-regional study comparing infrastructure provision in Spain and the United States, De la Fuente also concluded that causality flows from infrastructure investment to economic growth[11]. In 2004, using a panel framework and controlling for possible reverse causation, López found that infrastructure both raises economic growth and reduces income inequality[12]. In general, the evidence appears to suggest that an elasticity of output to infrastructure in the region of 0.2 might be reasonable if a number of other conditions also hold.

Mechansims by which infrastructure promotes economic growth

The different channels through which infrastructures can impact on both output and economic growth are well documented in the literature. Some of the most important of these are outlined below.

---

[8] Aschauer, D. (1989) Is Public Expenditure Productive? *Journal of Monetary Economics,* **23**, 2, pp 177-200

[9] Evans, P and Karras, G. (1994) Is Government Capital Productive? Evidence from a panel of seven countries, *Journal of Macroeconomics*, **16**, 2 pp271-279

[10] Button, K. (1998) Infrastructure Investment, Endogenous Growth and Economic Convergence, *Annals of Regional Science*, 32:1, pp 145-162

[11] De la Fuente, A. (2000) Infrastructures and Productivity: A Survey, *Barcelona, Instituto de Análisis Económico, CSIC, Working Paper.*

[12] López, H. (2004) Macroeconomics and Inequality, *The World Bank Research Workshop, Macroeconomic Challenges in Low Income Countries, October,* p20

Increasing market potential

One of the fundamental principles of economics, dating back to Adam Smith, is that greater specialisation can lead to increased productivity. However, this relies on a city/region/country being able to trade the goods/services that they specialise in for goods and services that other geographic regions are specialising in. Poor transport and communications infrastructure can inhibit this process by making trade prohibitively costly. Improvements in infrastructure therefore permit fuller specialisation and thus increase the potential for mutually beneficial trade.

Clustering

Recent developments in economic geography have focussed on the principle that 'proximity matters'. Firms locating close to other firms can benefit from knowledge transfers between firms and the 'economics of agglomeration'. They also become established centres and hence attract a dense network of specialised labour and suppliers. A large body of literature around this theme has been based on the benefits firms derive from clusters. Rice and Venables[13] attempted to estimate the effects of concentration directly, using UK data. They found that doubling the working-age population proximate to an area increases productivity by 3.5 per cent.

Improvements in transport and communication links can have an impact similar to that of clustering by *effectively* bringing firms closer together. This facilitates greater interaction between firms and hence allows for greater exploitation of agglomeration economies. Similarly, without an adequate water and sewerage system, any benefits derived from dense networks of people and firms would be offset by the inability to meet the basic needs of that population. [14]

Access to labour and inputs *(optimising the mix of inputs)*

Infrastructure development can affect GDP through allowing firms to better optimise their choices of inputs.[15] For instance, better transport connections can increase employment both by increasing the overall size of labour markets, and by ensuring a better match between employment vacancies and the skills of the labour force. Similarly, with a larger choice of suppliers, each firm can better select the specific type of input that is optimal for its particular production process.

Increased productivity *(diminishing costs for a given set of inputs)*

Infrastructures can also allow firms to use the inputs that they do have at lower cost. For instance, a well functioning transport network will raise productivity by reducing journey times (during which time people are unproductive) facilitating labour mobility, improving health and enabling effective competition even when economic activity is geographically dispersed. Similarly, adequate housing, heating and sanitation systems are vital for ensuring the health and well-being of the labour force and hence maintaining/increasing its productivity.

Response to structural changes

An effective transport system can help the economy respond to structural changes, for example by supporting commuter travel and allowing people to access work in growing industries.

[13] Rice, P and Venables A. J. (2004) 'Spatial determinants of productivity: analysis for the regions of Great Britain', CEP Discussion Paper #642, July

[14] Eddington, R. (2006) The Eddington Transport Study

[15] Eddington, R. (2006) The Eddington Transport Study

Conditions for infrastructure investment to impact on economic growth

While the balance of evidence suggests that infrastructure can assist in economic development, this research has also acknowledged that a number of other factors need to be in place in order to realise this link[16]:

- There must be a **favourable macro-economic climate**. If infrastructure provision is to lead to economic growth then provision of infrastructure must take place in an economic environment which is otherwise favourable to economic growth i.e. it must allow for the efficient allocation of resources, inflation should be low and stable.
- Other **inputs must be available**. Infrastructure development will not lead to economic growth if the key binding constraint on economic growth is entirely different i.e. skilled labour – although infrastructure development may make it easier for firms to access these other constrained inputs.
- **Tailoring of infrastructure supply.** It is necessary to consider the economic foundations of the demand before creating or expanding infrastructure. In other words, it is essential for the any new infrastructure to provide the reliability and quality of services in the right places that users actually value.
- **Consideration of non-market externalities.** As far as possible, user charges for infrastructure must reflect supply and demand conditions and also non-market externalities i.e. congestion. This will allow infrastructure to be used more economically efficiently (i.e. by those who value it most) and for recognition of the environmental costs associated with use of that infrastructure.

A final critical issue that determines the effectiveness of infrastructure development in promoting economic growth is the existing stock of infrastructure. As stressed by O'Fallon[17], it is possible for too much (new) infrastructure to be provided, and hence for the economic growth potential provided by infrastructure not to be maximised. The key concern with providing too much infrastructure is that it can draw scarce resources away from other important uses of resources, not least the maintenance and renewal of existing stocks.

This leads to the critical question as to whether or not England is currently under- or over-supplied in infrastructure. A full assessment of this issue is beyond the scope of this paper. However, a number of pieces of indicative evidence can be drawn upon to suggest that currently England is under-supplied in key infrastructure:

- It is estimated by DFT's National Transport Model that eliminating existing congestion on the road network – relative to free flow conditions – would be worth some £7—8 billion of GDP per annum
- A study undertaken by cebr examining the London economy for London First[18] developed a policy optimisation model to quantify the benefits of different policy interventions. Drawing on academic research to estimate the microeconomic impacts on productivity, so far as possible, it assessed the optimum expenditure mix and used this to assess the implications for London's long run economic growth. The results of this analysis suggested that the two key areas for the focus of government expenditure should be skills and education and transport infrastructure. In terms of the latter, it was estimated that an expenditure on London's transport system today of one million pounds would yield a benefit each year of around £120 000 in increased London productivity. This is

---

[16] Kessides, C. (1993) The Contributions of Infrastructure to Economic Development: A Review of Experience and Policy Implications, *World Bank discussion paper No 213*

[17] O'Fallon, C. (2003) Linkages between Infrastructure and Economic Growth, Prepared for the Zew Zealand Ministry of Economic Development, December

[18] cebr (2006) Keeping the UK Competitive

corroborated by the finding that over 97 per cent of City of London companies believe that productivity of their staff is reduced by problems faced in commuting.[19]

- As reported in the Interim Report by the Barker Review into Land Use Planning[20], British Chambers of Commerce data provide evidence that some businesses are choosing not to expand, or to move out of an area because of transport failures. For instance, the data suggest that 46 per cent of businesses attribute a lack of investment in their region to the transport infrastructure and 76 per cent of businesses report increased operating costs as a result of transport failings.
- The same report also cites an estimate that a new energy supply infrastructure of around £10 billion is needed to increase the UK's capacity to import and store gas by 2010.
- Catalyst Corporate Finance have estimated that £9bn will need to be invested in fifty new incineration and treatment facilities in order to cut the amount of waste dumped in landfill to just twenty per cent by 2020.[21]

Conclusions

It is generally recognised that the provision of infrastructure and economic activity are positively related i.e. that a higher levels of economic activity are seen in countries with more infrastructure. However, the direction of causality between this empirical regularity has been more controversial: some academics have claimed that more (and better) infrastructure leads to higher levels of economic activity, by contrast others have argued that economic growth leads to more infrastructure being provided. In recent years, the balance of (but not all) technical econometric work has suggested that the causal relationship flows from infrastructure to economic growth and activity.

The consensus view that emerges from this work is that there is a positive elasticity of output to public capital of around 0.20. Put another way, a ten per cent increase in public capital stock (infrastructure) would be expected to, on average, increase GDP by around two per cent[22].

However, the efficacy of infrastructure investment in promoting economic growth will differ over time and between infrastructure projects. A number of pre-conditions need to be met in order for an infrastructure project to maximise its contribution to economic growth. These include a benign macroeconomic environment; infrastructure projects which are tailored to needs and, as such, overcome current constraints/'pinch-points' in the economy; user-charges for any infrastructure which encourage its efficient use; and striking the correct balance between the maintenance and renewal of existing infrastructure versus development of new infrastructure.

A further, particularly important, criterion for infrastructure to assist in economic growth is that the economy is currently under-supplied in infrastructure. This will reduce the risk of infrastructure development diverting resources from other, more valuable, activities. A full assessment of this issue in the England/UK context is beyond the scope of this report although a number of pieces of evidence all suggest that the economy is not currently over-supplied of infrastructure.

Given the various conditions that need to be fulfilled before infrastructure will promote economic growth it is appropriate to conclude with the conclusion reached by Kessides — infrastructure alone cannot create economic potential: it can only develop it where appropriate conditions already exist.

---

[19] Corporation of London (2003) The Economic Effects of Transport Delays in the City of London.
[20] Barker, K. (2006) 'Land use planning: interim report' July
[21] As cited in the Financial Times, January 4th 2008
[22] Eddington, R. (2006) The Eddington Transport Study , Volume 1, p10

Appendix 5

VALUING THE ENVIRONMENT: DIFFERENT APPROACHES

Attempting to place a value on the environment and hence on the ‘consumption’ of the environment is made difficult as it is (largely) a non-traded good. For instance, while the value of diamonds can be ascertained by how much people are prepared to pay for an additional diamond in a transaction, there is no immediately equivalent transaction which represents the value attributed to the environment. Consequently, alternative approaches to assessing value need to be derived. In doing this, two alternative concepts of value can be distinguished.

Use value is the value associated with the consumption of the good. In the case of an environmental good this could include current use (“I am currently visiting the park”), expected use (“I plan to visit the park later this year”), or possible use (“I might visit the park within the next ten years”).

Non-use value is a more controversial aspect of value. In general, this would include the value placed on a good which does not involve direct participation. Non-use value can be comprised broadly of three types of value:

- Bequest value: the value associated with the well-being of future generations,
- Altruistic value: satisfaction gained from another individual’s enjoyment and
- Existence value: the value an individual attaches to knowing something exists.

Examples of **non-use** value would include, for instance, the value placed on simply knowing that a particular species of animal or wilderness exists.

In this context, a number of different approaches have been devised to attempt to derive valuation estimates. We consider:

- Contingent valuation (CV)
- Hedonic pricing
- Defensive expenditure
- Experimental markets
- Voter referendum

Contingent valuation

Contingent valuation (CV) is an approach which, at its simplest, asks people to place a value on how much they would be prepared to pay—their willingness to pay (WTP)—in order for the non-market good/service to be supplied. The approach has been most widely used for valuing different kinds of environmental goods. However, it has also been used to assess other non-market goods including the value of an individual’s life (or health), the level of crime within a city, as well as leisure time.

The most significant benefit of this approach is that it can, in certain circumstances, provide accurate estimates of the values of non-market goods. In particular, CV was accepted by the National Oceanic and Atmospheric Administration (NOAA) panel in 1993, co-chaired by the Nobel Laureates Kenneth Arrow and Robert Solow, who concluded that CV studies conveyed ‘useful information’ for damage assessment, provided they follow a number of stringent guidelines.[23] Specifically, the NOAA panel stressed the important role that the method has in eliciting non-use values which alternative methods are unable to assess.

This relates to the second key advantage of this method which is that it is very flexible and can be adapted to estimate the economic value of almost any good or service. The alternatives to the approach have many limitations which restrict their use. By contrast, CV is a very broad ranging method.

However, there are also a number of disadvantages associated with contingent valuation studies.

First, the primary criticism identified with contingent valuation is that the values elicited in CV surveys are not based on real resource decisions and therefore the response to a WTP question may be unrealistically high. For instance, respondents may express a positive willingness to pay in order to feel good about the act of giving, although they believe the good itself is unimportant. This is known as the ‘warm glow’ effect and its existence is due to the respondent’s ability to be dishonest without bearing the consequences.

Second, a further problem faced by this approach is that respondents may express different willingness to pay amounts contingent upon the hypothetical way in which it is assumed payment will be made. For example, some payment vehicles such as taxation may elicit significantly lower values from respondents as opposed to payment via contribution or donation, as individuals dislike the idea of increased taxes.

Third, information bias can often occur in CV studies where respondents are asked to value environmental goods of which they have no prior knowledge or experience. This can therefore mean they are susceptible to influence by information presented when interviewed.

Fourth, there are some practical problems with the approach. In particular they can be very expensive and time consuming to conduct, involving extensive pre-testing and survey work. Furthermore, it can be difficult to validate the results of non-use values.

Hedonic Pricing

The hedonic price method entails assessing environmental values based upon revealed preference (observing the behaviour of actual market transactions) as opposed to the CV method of stated preference.

An example of a simple hedonic price study would be assessing the impact of air pollution on the market value of house prices. The method would involve assessing the house price differential between similar houses within a polluted and unpolluted area. As the houses compared are similar, the house price differential can be seen as reflecting the residents WTP to have lower levels of pollution or willingness to accept (WTA) to tolerate higher levels of pollution.

Hedonic price studies must therefore control for other factors which influence house prices including structural variables of the house (e.g. number of rooms, size of garden, furnished or unfurnished, etc) as well as neighbourhood variables and amenities (e.g. crime rates, distance from city centre, quality of transportation infrastructure, number of parks, etc).

The main advantage of hedonic pricing studies is that as they are based on real market decisions. As such, there is a degree of objectivity about the results that a contingent valuation study — given the problems already discussed — lacks.

There are a number of disadvantages, however, to using this method of valuation. One of the major limitations of the hedonic price analysis is that it can only be used to value non-market goods which have an impact on the price of market goods (e.g. house prices effected by air pollution as in the case described above). There are a number of environmental problems which

[23] Arrow, K, Solow, R., Portney, P., Leamer, E., Radner, R., Schuman, H. (1993) ‘Report of the NOAA panel on contingent valuation’ January

do not have an impact on the price of market goods such as the loss of a species of plant or animal for which the analysis would be ineffective.

In addition, the hedonic price method suffers from being based on the assumption that the damage incurred by the environmental commodity is perfectly reflected in the price of the market good i.e. in the property price in the example above. This is not necessarily true as residents may spend a considerable proportion of their day away from their home and therefore not fully absorb the damaging effects.

Defensive expenditure

Another method by which real market decisions can be used to obtain WTP estimates is through valuing an individual's **defensive expenditure** in removing or reducing a negative environmental impact. For example, if an individual is impacted by the noise created by a nearby airport, the amount the individual is willing to pay for sound proofing his home will serve as a monetary estimate of the damage caused to the individual. However, the defensive expenditure method can only be used for negative environmental impacts. For positively valued environmental goods such as national parks, the corollary might be considered to be the travel expenditure incurred in visiting the park. However, this method can only be used to elicit a minimum WTP value of such a recreational goods: people may have been willing to pay much more but just did not have to.

Experimental markets

Another method similar to the CV approach is the **experimental markets** method. The CV approach as mentioned above is based on a hypothetical situation which lacks any real resource commitment. Experimental markets involve the actual exchange of money for a real good. The disadvantage of using experimental markets, aside from implying greater costs, is that it is more difficult to turn hypothetical situations such as a destruction of a rainforest into a real scenario which the respondent will take seriously.

Voter referendum

A final alternative is to take a **voter referendum** upon the environmental good in question, making clear that a tax levy would need to be accompanied for its successful implementation. Under the assumption that those with the highest value for the good are the most likely to vote in favour, the demand function can be inferred by identifying the prices (the increase in taxation) faced by each person and observing how the individual votes.

The referenda method overcomes some of the shortcomings of the CV method as the environmental good in question is real, the decisions made are binding — meaning individuals will be forced to pay the tax if the referendums outcome is in favour of provision — and individuals are well informed of the arguments for and against provision through a lengthy pre-election campaign. The disadvantage of this approach is that balloting is confidential and it is only possible to observe how groupings of voters vote and utilise the characteristics of the groupings to explain the vote. They are also, in many cases, impractical and expensive.

Conclusions

This brief review of the different approaches that can be made to assess the environmental costs associated with a particular activity indicates that no approach is without problems. For instance, contingent valuation has the significant drawback that it asks for people's assessment of their WTP/WTA without this opinion needing to be backed up by an actual resource commitment. On the other hand, other approaches to assessing the environmental costs are either implausibly expensive and/or impractical in most contexts e.g. a voter referendum, or only imperfectly capture any environmental costs by omitting non-use values e.g. defensive expenditure or hedonic price approaches.

Notwithstanding the problems associated with the contingent valuation approach, this report proposes therefore to use this approach to attempt to estimate the environmental costs associated with aggregates extraction. As noted by Nobel Laureates Kenneth Arrow and Robert Solow, CV studies convey 'useful information' on environmental costs. Further, there is also the advantage that there is a readily available data source which has used this data source.

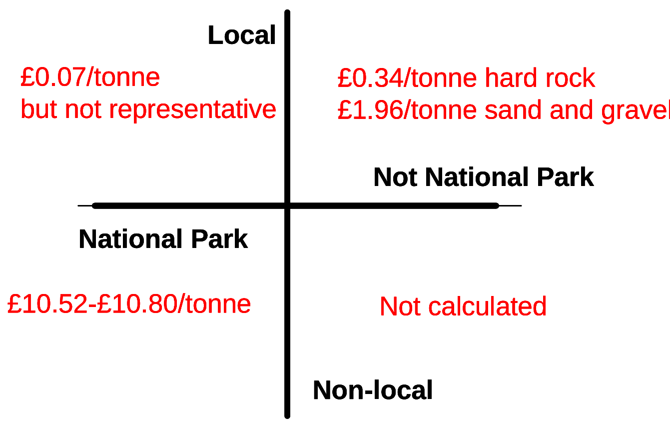
CONTINGENT VALUATION OF AGGREGATES EXTRACTION IN ENGLAND: PREVIOUS WORK

London Economics paper

The most extensive research project aimed at deriving estimates on the environmental damage caused by aggregates extraction — in terms of amenity value reduction — in England was a study conducted by London Economics to inform the debate on the Aggregates Levy.[24]

The results of this study into the environmental costs of aggregates extraction can be divided along two dimensions. These are shown, along with the respective results in the figure below.

Estimates of Environmental Damage from Aggregates Extraction



Source: London Economics (1999)

The difference between national park and non-national park is clear. The difference between local and non-local (or national) WTP is that local estimates capture the costs felt in the immediate vicinity to the quarry in terms of noise and air pollution etc. By contrast, non-local effects capture the costs borne by non-local residents resulting from both non-use values as well as the use-value associated with tourists etc.

The figures cited by the report as being reliable for use are the non-local National Park and the local non National Park estimates. This excludes two components from the analysis: the local, National Park value and the non-local, non National Park values. For local National Park estimates (top-left quadrant), it is clear that the unrepresentative (and hence unreliable) valuations are very low, while the tonnage figures from National Parks will also be relatively low. For the non-local, non national park estimates (bottom-right quadrant) it is plausible that these figures would be low on the grounds as people will plausibly place considerably less value on environmental damage that they are not immediately affected by, in non National Park[25] areas.

[24] London Economics (1999) The Environmental Costs and Benefits of the Supply of Aggregates—Phase 2, July
[25] Although research into environmentally sensitive, non-National Park areas e.g. SSSIs was not undertaken as part of this project

Updating the London Economics work

The London Economics study was controversial for a number of reasons. Some objected to the principle of trying to place a monetary value on environmental damage. However, if an attempt is to be made to understand the environmental costs of the industry — in a way which can be compared with its benefits — then such an exercise is necessary. Furthermore, as Pearce and Seccombe-Hett (2000)[26] note:

> monetisation is simply a convenient means of expressing the relative values that society places on different uses of resources. Valuation is a means of measuring public preferences for environmental resources and is not a valuation of those resources in themselves (so-called intrinsic values).

Beyond this objection in principle, a number of other concerns were expressed in terms of its implementation. Prime among these were whether or not the study gave full account to the environmental benefits associated with aggregates extraction, specifically in terms of the restoration of the land after extraction has completed. As noted by Mourato and Pearce in a peer review of the first piece of work undertaken by London Economics (which was subsequently revised to provide the estimates stated above):

> While the study is intended to estimate the value of disamenity (costs) and benefits, there are in fact no estimates of the benefits that could come from quarry restoration. We are unable to say what bias this imparts to the estimates.

The heart of this issue appears to rest in the question asked to respondents and how this relates to actual practice by quarry operators. In the survey, people were asked how much they would be willing to pay to close a quarry and restore the area to a standard 'in-keeping with the surrounding landscape'. If, however, a typical restoration leads to an improvement in the landscape compared with the surrounding area then this would represent an environmental benefit of the aggregates sector which was not captured by the London Economics study.

In this context, the findings from a study by Damigos and Kaliampakos are interesting.[27] They report the outcome of a contingent valuation study regarding the reclamation of a quarry site in Athens of approximately twenty hectares and from which two and a half million cubic metres of aggregates had been extracted into the 1970s. At the northern section wastes from earthworks and demolitions had been removed whilst the southern section had not been touched i.e. restoration had not been to a level in-keeping with the surrounding area. In the study, respondents were asked to place a value on three alternative reclamation projects:

1. Reforestation. This would involve no change to the topography; the planting of 10 000 plants, creation of footpaths and observation stands.
2. Backfilling of the area plus reforestation. This involved back-filling to establish the original contour, the planting of 15,000 trees and the construction of footpaths and observation stands.
3. Partial backfilling, reforestation and installation of new land uses.

The results from this study are provided in the table below.

Factor	Willingness to Pay per household (€)	Estimate of aggregates benefit (€)
Alternative 1	29.44	237 670
Alternative 2	45.88	447 880
Alternative 3	56.44	508 580

Source: Damigos and Kaliampakos (2003)

[26] Pearce, D. and Seccombe-Hett, T. (2000) 'Economic Valuation and Environmental Decision-Making in Europe.' *Environmental Science and Technology*, **34**, 1419-1425

[27] Damigos, D. and Kaliampakos, D. (2003) Assessing the benefits of reclaiming urban quarries: a CVM analysis, Landscape and Urban Planning, **64**;3, August

In total, the figures do suggest that there is an environmental benefit associated with the reclamation of abandoned quarries. However, it should be noted that this represents an environmental benefit relative to the situation in which the site was previously disused. Therefore, while the study suggests that there are environmental benefits associated with quarry reclamation it (unfortunately) cannot directly inform the extent to which these were not captured adequately by the London Economics study.

Furthermore, while the evidence above is suggestive of there being environmental benefits from reclamation projects following extraction (and which may not have been captured in the London Economics study), the study itself suggested that the cost estimates themselves were deliberately conservative i.e. low. For instance, the use of a willingness to pay methodology was used rather than a willingness to accept approach, the survey approach excluded residents more than five miles from a quarry and the fact that the only environmentally sensitive landscapes considered were National Parks were all cited by the authors as reasons why the figures derived were likely to be conservative.

Consequently, in the absence of better data, and also recognising that it is a somewhat unsatisfactory approach, we propose to continue to adopt, as a baseline, the willingness to pay estimates derived in the London Economics study as the best current estimates available.[28]

However, an important issue that arises in making use of data collected in 1999 when trying to derive more up to date estimates of environmental damage is whether changes between these two dates mean that adjustments to the values derived need to be made. In particular, between 1999 and the current day income levels have risen. For most goods (known as 'normal goods') when income levels increase, demand for the good increases. However, there are some cases where higher incomes leads to lower demand ('inferior goods')[29]. In exactly the same way that the relationship between market goods and incomes can be evaluated so can the relationship between non-market goods such as a 'clean environment' and income be assessed.

Consequently, a brief review of the academic literature was undertaken to consider two related questions:

- Are environmental goods a normal good i.e. will WTP estimates increase as income levels increase?
- If they are normal goods, when income increases, is the proportionate increase in WTP greater or less than the proportionate increase in income (in the former case, the good is 'income elastic' or a 'luxury' good, in the latter case it is income inelastic).

A study conducted by Grossman and Krueger[30] examined the effect upon environmental quality as income increased. The four environmental indicators specifically analysed were urban air pollution, the state of the oxygen regime in river basins, faecal contamination of river basins, and contamination of river basins by heavy metals. The study found there was no evidence to suggest that environmental quality steadily deteriorates with economic growth. For most indicators the research found that economic growth causes the environment to suffer an initial phase of deterioration which is followed by a subsequent phase of improvement. This would suggest that as income levels increase, the demand for environmental good increases and so willingness to pay estimates would also increase.

---

[28] As part of the project, a comprehensive academic literature review was undertaken to see if there were any more recent studies on the values placed by the environmental damage caused by aggregates extraction which could be used to update/corroborate the findings from the 1999 paper discussed above. Regrettably, the outcome of this review was that there were no papers that could be drawn on for this purpose.

[29] Bus/coach travel is often used as an example of an inferior good: when incomes rise people tend to switch to car, rail or air travel.

[30] Grossman, G. M., Krueger, A. B., 'Economic Growth and the Environment', *The Quarterly Journal of Economics* 110:2, 1995, pp 355 – 377.

The study described above particularly found that while increases in GDP are associated with worsening environmental conditions in many developing countries, air and water quality appear to improve once income has reached a critical level (in most cases) of less than $8000 (1985 dollars) per capita.

A World Bank Development report (1992)[31] also shows a similar U-shaped relationship between income per capita and environmental damage; however the turning points within the World Bank report appear to be at lower levels of income than suggested by the Grossman and Krueger study. Although many environmental variables appear to suggest an initial deterioration followed by an improvement, the World Bank data on municipal waste per capita and carbon dioxide levels show, by contrast, a worsening in environmental conditions as income levels increase.

A study by Kriström and Riera[32] used a number of contingent valuation data sets from across Europe to calculate the income elasticity of environmental improvements. The study found, with few exceptions, that the income elasticity was between 0 and +1 suggesting the environment is considered to be a normal good. This is consistent with non-contingent valuation data from the *Wall Street Journal*[33] which showed that donations to environmental causes decrease as a percentage of income, as income levels rise (except at very high income levels).

The implications for this analysis is that in updating the analysis from the 1999 study it is likely that WTP values have increased (ie that environmental protection is a normal good). However, it also suggests that they are likely to have increased proportionately less than income levels have in the intervening period i.e. that the demand for the environment is income inelastic.

---

[31] World Bank, World Development Report 1992: Development and the Environment, (Washington, DC: The World Bank, 1992).
[32] Kriström, B. and Riera, P. (1994) Is the income elasticity of environmental improvements less than one?, Evidence from Europe and other countries *2nd International Conference on Environmental Economics, Ulvon, Sweden*
[33] U.S. tax data, *Wall Street Journal* 6/16/93, p. 1

References

BARKER, K. 2006. Land Use Planning: Interim Report. *Department for Communities and Local Government, available online at:http://www.communities.gov.uk/planningandbuilding/planning/planningpolicyimplementation/reformplanningsystem*

BBC. 2008. UK house prices. *Available online at: http://news.bbc.co.uk/1/shared/spl/hi/in_depth/uk_house_prices/html/houses.stm*

BRITISH GEOLOGICAL SURVEY (BGS). 2007a. Collation of the results of the 2005 Aggregate Minerals Survey for England and Wales. *Department for Communities and Local Government, available online at: http://www.communities.gov.uk/publications/planningandbuilding/aggregatesmineralssurvey2005*

BRITISH GEOLOGICAL SURVEY (BGS). 2007b. The United Kingdom Minerals Yearbook. *Available online at: http://www.bgs.ac.uk/mineralsuk/commodity/uk/ukmy.html*

BRITISH GEOLOGICAL SURVEY (BGS). 2008a (in press). The need for indigenous fluorspar production in England.

BRITISH GEOLOGICAL SURVEY (BGS). 2008b (in press). Aggregate resource alternatives: Options for future aggregate mineral supply in England.

BUNKER BULLETIN DAILY. 2007. Daily bulletin available by subscription. *Bunker costs are also available online at: http://www.bunkerworld.com/markets/prices/?tag=0-4411-4578717-0*

CAPITAL SYMONDS. 2006. Survey of Arisings and Use of Alternatives to Primary Aggregates in England, 2005. *Department for Communities and Local Government, available online at: http://www.communities.gov.uk/publications/planningandbuilding/surveyuse*

CENTRE FOR ECONOMICS AND BUSINESS RESEARCH LTD (cebr). 2006. Keeping the UK Competitive. *Available online at: http://www.london-first.co.uk/documents/082_Keeping_the_UK_Competitive_-_full_report.pdf*

CORPORATION OF LONDON. 2003. The Economic Effects of Transport Delays in the City of London. *Available online at: http://www.cityoflondon.gov.uk/Corporation/business_city/research_statistics/Archived+reports+2000-2005.htm*

DEPARTMENT FOR COMMUNITIES AND LOCAL GOVERNMENT (CLG). 2007. Homes for the Future: More Affordable, More Sustainable. *Housing Green Paper http://www.communities.gov.uk/publications/housing/homesforfuture*

DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS (DEFRA). 2007a. UK Climate Change Programme, Annual Report to Parliament. *Available online at: http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/ukcc-annrpt-07.pdf*

DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS (DEFRA). 2007b. The social cost of carbon and the shadow price of carbon: what they are, and how to use them in economic appraisal in the UK. *Available online at: http://www.defra.gov.uk/environment/climatechange/research/carboncost/pdf/background.pdf*

DEPARTMENT FOR TRANSPORT (DfT). 2007. Maritime Statistics. *Available online at: http://www.dft.gov.uk/pgr/statistics/datatablespublications/maritime/compendium/*

DREWRY (2007) Dry Bulk Insight, Issue 43, October 2007

EUROPEAN UNION (EU). 2008. Emissions Trading Scheme (EU ETS). *Details available online at: http://ec.europa.eu/environment/climat/emission.htm*

KESSIDES, C. 1993. The Contributions of Infrastructure to Economic Development: A Review of Experience and Policy Implications. *World Bank discussion paper No 213*

LONDON ECONOMICS. 1999. The Environmental Costs and Benefits of the Supply of Aggregates – Phase 2. *Department for Communities and Local Government. Available online at: http://www.communities.gov.uk/archived/publications/*

MDS TRANSMODAL. 2006. UK Port Demand Forecasts to 2030. *Department for Transport. Available online at: http://www.dft.gov.uk/pgr/shippingports/ports/portspolicyreview/*

MDS TRANSMODAL. 2007. Update of UK Port Demand Forecasts to 2030 and Economic Value of Transhipment Study. *Department for Transport. Available online at: http://www.dft.gov.uk/pgr/shippingports/ports/portspolicyreview/*

O'FALLON, C. 2003. Linkages Between Infrastructure and Economic Growth. *Prepared for the New Zealand Ministry of Economic Development. Available online at: http://www.med.govt.nz/templates/MultipageDocumentTOC____9187.aspx*

OFFICE FOR NATIONAL STATISTICS (ONS). 2006a. Mineral Extraction in Great Britain 2005. Business Monitor PA1007. *Based on the Annual Minerals Raised Inquiry, carried out for Department for Communities and Local Government and Department for Trade and Industry (now Department for Business, Enterprise and Regulatory Reform). Available online at: http://www.statistics.gov.uk/default.asp*

OFFICE FOR NATIONAL STATISTICS (ONS). 2006b. Annual Business Inquiry 2005. *Available online at: http://www.statistics.gov.uk/default.asp*

OFFICE FOR NATIONAL STATISTICS (ONS). 2007a. Input-Output Annual Supply and Use Tables, part of the United Kingdom National Accounts. *Available online at: http://www.statistics.gov.uk/default.asp*

OFFICE FOR NATIONAL STATISTICS (ONS). 2007b. Environmental Accounts, Autumn 2007 (also available in the United Kingdom National Accounts). *Available online at: http://www.statistics.gov.uk/default.asp*

PRB ASSOCIATES. 2007. Quotation for port charges from Humber International Terminal at Immingham obtained verbally from the Port Authorities.

QUARRY PRODUCTS ASSOCIATION (QPA). 2007. Carbon Reduction Statement of Intent. *Available online at http://www.qpa.org/downloads/cstate.doc*

STOPFORD, M. 1997. Maritime Economics. *Routledge* ISBN:0415153093

WASTE AND RESOURCES ACTION PROGRAM (WRAP). 2006. The Sustainable Use of Resources for the Production of Aggregates in England. *Available online at http://www.aggregain.org.uk/sustainable_2.html*