



The economic benefits of chemistry

The RSC commissioned a report to examine how much chemistry research contributes to the UK economy

The products of chemistry research are all around us, from the water we drink and the food we eat, to the clothes we wear, the cars we drive and the energy used to heat and light our homes. Chemistry research has changed our way of living and increased our quality of life.

The Engineering and Physical Sciences Research Council and the Royal Society of Chemistry commissioned an independent study to examine the many channels through which chemistry research contributes to the UK economy and to provide a quantitative and qualitative analysis of just how much it benefits the UK. Here is a summary of the key findings of the resulting report, prepared by Oxford Economics.

The evidence presented in the report shows that the direct and indirect ('spillover') benefits from fundamental chemistry research are significant to the UK. More crucially, it will be the outcomes of this fundamental research that will be a vital ingredient in helping to answer important technical and societal challenges facing the UK in the years ahead.

The report headlines

Chemistry-reliant industries contributed £258 billion value-added to the UK economy in 2007 – equivalent to 21% of UK GDP – and supported 6 million jobs, accounting for at

least 15% of the UK's exported goods and attracting significant inward investment.

Furthermore, the quality of UK chemists and the reputation for excellence of the UK's science base significantly influences companies choosing to locate in the UK, or to retain a UK-based research presence.

The UK's chemistry-reliant industries can be split into two categories: the 'upstream', consisting of chemical-producing industries; and 15 identified 'downstream', chemical-using industries (which include, for example, the aerospace, automotive, electronics, health and textiles industries).

Upstream: £36bn and 800,000 jobs

The upstream chemicals industry is an enabling industry, helping provide technological solutions to many challenges faced by other parts of the economy – it underpins sustainability in downstream industries such as healthcare, electronics, and textiles.

Interviewees reported that chemistry research is essential in keeping their businesses competitive through innovation, meeting evolving customer needs, and responding to market pressure from regulatory and environmental concerns. The study concludes

In summary

- The UK's 'upstream' chemicals industry and 'downstream' chemistry-using sectors contributed a combined total of £258 billion in value-added in 2007, equivalent to 21% of UK GDP, and supported over 6 million UK jobs.
- Workers in the UK's chemicals industry are highly productive – at £83,500 per employee (2007) the sector has a labour productivity more than double the UK average.
- The UK's chemicals industry is a major source of UK exports, accounting for 15% of the goods exported by UK companies.
- UK chemists are internationally renowned for their quality and are shown to be a significant factor in causing companies to locate in the UK, or retain a UK-based research presence.

that the upstream chemicals industry is 100% dependent on chemistry and chemistry research.

On that basis, chemistry research in the upstream industry contributes £17 billion in GDP directly, providing 200,000 jobs. Oxford Economics estimates that the wider impact of the upstream chemicals industry, incorporating indirect and induced effects in the domestic supply-chain, is that it supports over 800,000 jobs contributing £36 billion to the UK's economy in 2007. This is equivalent to 3.1% of UK GDP.

These figures are only a one-year impact; the industry has been contributing to the UK economy for many years, generating substantial revenues for the Exchequer via corporation and sales taxes.

The upstream chemicals industry is one of the UK's highest exporters, accounting for 15% of the UK export of goods, comparable to the UK's transport equipment sector, which includes famous global brands such as Rolls-Royce aerospace and Bombardier trains. The chemistry research-reliant pharmaceuticals industry is the third largest exporting sector in the UK. Trade performance is a key determinant of economic growth and prosperity. Innovative exploitation of fundamental research discoveries enables UK industries to improve their price and product competitiveness in a global market.

Downstream: £222bn and 5.1 million jobs

Oxford Economics determined that the 15 identified downstream industries, in which chemistry research is a necessary (but not the only) condition for their operation, support an additional 5.1 million jobs and directly contributed £222 billion to the UK's GDP in 2007.

Chemistry research impacts on the downstream sector indirectly through inputs purchased from the upstream industry. However, it also has a direct impact, as businesses in the downstream sector often conduct chemistry research in collaboration with academic research centres.

A methodological framework was used to determine the extent of dependence on chemistry research of different sectors across the economy (see page 3). This involved applying a weight to each industry



according to their dependence on chemistry research, based on consultations with industry stakeholders and desk-based research. The data shows that the chemistry-dependent share of the downstream industries contributes a value-added of £222 billion, equivalent to 18% of UK GDP and, within the downstream industries, chemistry research supports 5.1 million jobs. The approach for downstream industries does not consider their indirect and induced impact as this would lead to some double-counting; therefore this overall estimate is conservative.

Through stakeholder interviews it was discovered that there is less emphasis on conducting fundamental research in-house by businesses operating in the downstream industries. Instead, businesses access this knowledge by building strategic relationships with upstream

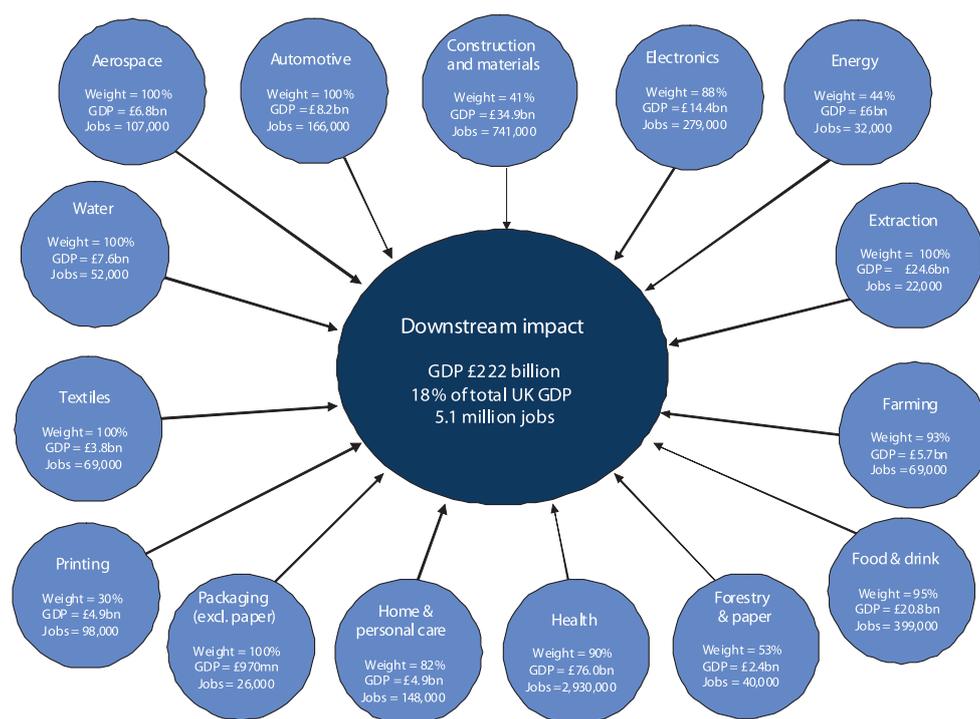
companies, academia and research centres, but also less formally by monitoring academic publications and attending conferences; the latter is viewed as a useful way to keep on top of the latest developments in fundamental chemistry research, with a view to spotting commercial applications.

Much of the chemistry-based research effort conducted by downstream businesses involves using fundamental principles of chemistry to 'tweak' existing products to meet more immediate needs. Downstream businesses emphasise the value of the skills available in the UK workforce as a result of training in chemistry research to facilitate this work. It is these researchers who are best placed to make the small incremental changes in processes and materials that can give their companies an advantage over their competitors.

Fundamental chemistry research has a crucial role

The economic and social returns we enjoy today reflect the fruits of many years of investment in chemistry research, and ongoing fundamental research is essential to ensure a continuing flow of scientific and technological breakthroughs. Undertaking this research in universities, research centres and in industry ensures that the UK maintains a highly skilled

● **Figure 1: The direct contribution of the downstream chemistry-using industries to UK GDP and employee jobs, 2007 (constant 2005 prices)**





and innovative workforce and is well placed to adopt and advance new ideas, successfully exploit new technologies and develop new and better products and services. This will fuel economic activity, and is a necessary condition for attracting inward investment to the UK.

Apart from the economic benefits, the study recognises that fundamental research is also indispensable to the search for answers to some of the most important technological and societal challenges facing both the UK and the wider world. It communicates case study examples of chemistry in the areas of climate change, energy, food supply, security and health.

While the study is focused on benefits at a UK level, it is clear that UK-based chemistry research has additional significant international benefits.

Beyond simple metrics

The report highlights that chemistry research helps to enhance the performance of the wider UK economy beyond simple economic and financial metrics. It helps enhance the performance of the wider economy in a number of ways.

Maintaining and enhancing the reputation of the UK science base

The UK has many world-leading chemistry research departments and specialist research centres. The latest (2008) Research Assessment Exercise classed 12 chemistry/chemistry-related departments as world-leading or internationally excellent, while the 2009 International Review of UK Chemistry Research highlighted world-class and often world-leading research areas

including chemical biology, materials and supramolecular chemistry. Cutting-edge chemistry research maintains the UK's science base and the ability of universities to compete for staff, (international) students and research contracts.

Providing a skilled and innovative workforce

UK chemistry PhD programmes are recognised by industry as providing an innovative workforce able to pose and answer difficult questions. Stakeholder interviews suggest that UK postgraduate training in chemistry provides an edge in the corporate world: a remarkable number of UK-trained chemistry PhDs either occupy senior positions in leading multi-national companies such as BP and Novartis, or have set up successful spin-out companies to exploit their PhD research.

Analysis of the first destination of UK chemistry doctoral graduates shows that research remains an important occupation once study is complete, with 60% entering research-based jobs (half of these are outside academia). This is compared to 43% of all doctoral leavers in engineering and physical sciences who remain in research-based positions.

The UK's upstream 'chemicals industry' workforce is the fourth largest in terms of the proportion educated to at least degree level, and generated a labour productivity in 2007 of £83,500 per worker – more than double the UK average (£37,500). By comparison, the industry is more productive than the UK motor industry and produces over 80% more output per worker than across manufacturing as a whole.

Attracting inward investment and creating trade benefits

Stakeholders indicate that the quality of UK chemists is a significant factor in causing companies to locate in the UK, or to retain a UK-based research presence. Examples of companies that have made significant investments in the UK chemicals sector include:

- Saudi Basic Industries Corporation (SABIC), which has invested £300 million acquiring the world's largest polyethylene plant in the North East of England;

Quantifying the impact of chemistry

To quantify the impact of chemistry research to the downstream industries, Oxford Economics sought to identify the extent of dependence on chemistry research across different downstream sectors of the economy. A four-stage approach was followed.

(i) Analysis of expenditure on upstream chemicals by the downstream industry

This identifies the level of purchases made by the downstream industry directly from the upstream sector.

(ii) Analysis of expenditure on chemistry-using industries by the downstream industry

Downstream chemistry-using industries also purchase inputs from a range of industries that in turn are chemistry-using e.g. the automotive industry buys £1.1 billion of tyres and other rubber products from the rubber and rubber products industry.

(iii) Weight the dependence on chemistry research of the downstream industry

Weighting figures provide a measure of how important chemistry research is in enabling the sector to operate. For example, the water distribution industry purchases just 3% of its inputs from the chemicals sector, suggesting a low level of dependence on chemistry research. However, these chemicals are used for purification, without which there would be little demand for distributed water. Therefore, the water distribution industry is deemed to be entirely dependent upon chemistry research.

(iv) Derive the size of the chemistry-dependent downstream industry

Multiplying the GDP and employment in each sector by the associated weighting provides a chemistry-related GDP and employment figure for each sector (see Figure 1).

Maximising impacts

Maximising the impact of chemistry research for the benefit of UK plc requires publicly funded, multidisciplinary teams of scientists and high levels of collaboration between academia and industry. Oxford Economics carried out stakeholder consultations in order to explain how the UK can make the best use of the UK's science base.

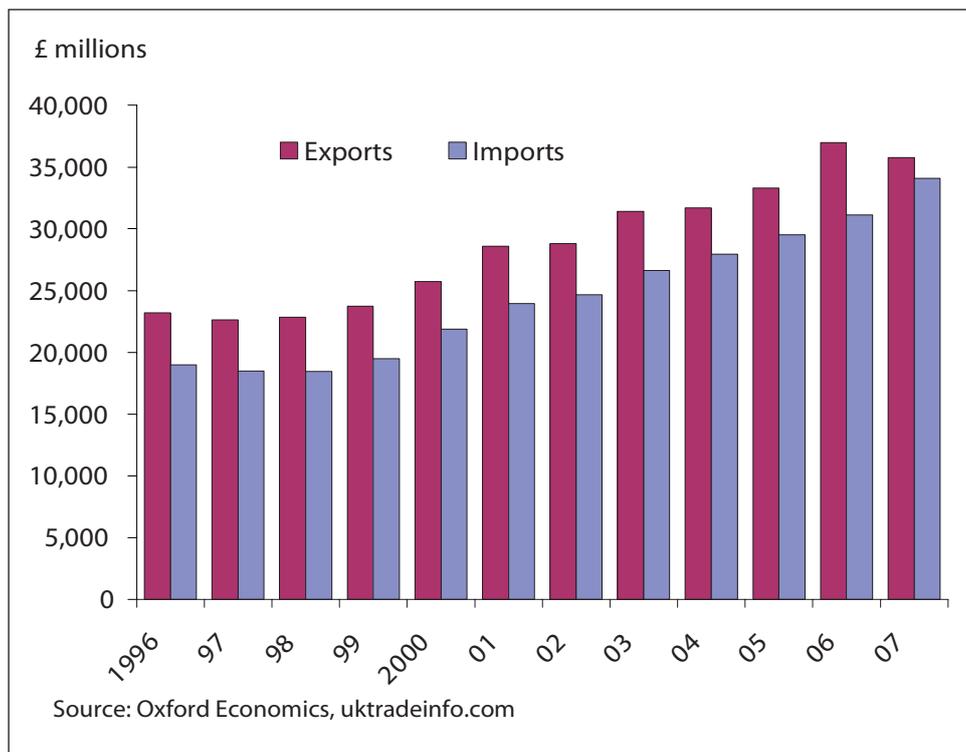
In the process of research, discovery and innovation, chemistry works in tandem with other science disciplines including physics, biology, biotechnology and material science; this is demonstrated in many of the report's case studies.

Collaborative and strategic partnerships between academia and industry are also crucial to enhance the two-way flow of knowledge between these sectors. They accelerate the speed with which new products can get to market, and thus help assure the UK has 'first-mover advantage'. However there were mixed opinions on the most effective way to organise collaborations and the study concludes that several different forms of strategic relationships are required, rather than a one-size fits all strategy.

Conducting fundamental research is both costly and risky to the private sector. The benefits from research often only translate into impact years or even decades later; they are also rarely confined to the firm or research institution conducting the original research (even in the presence of patents), but instead spill over to society at large. For these reasons private sector investment in fundamental chemistry research will be sub-optimal for the economy as a whole. This is often referred to as market failure, and justifies continued support from the public purse.

Policy makers and the Royal Society of Chemistry will be using the results of this report to emphasise the true value that chemistry brings to the UK economy. The economic impact of fundamental chemistry research reaches far beyond any single sector and the UK cannot afford to let funding in this area diminish.

For the full report, visit the website.
www.rsc.org/chemistryimpact



● **Figure 2: Trade performance of the upstream chemicals industry, 1996-2007**

● Ensus, which is investing £200 million in building Europe's largest bioethanol refinery (also in the North East);

● Victrex's £32 million polymer manufacturing plant in Lancashire;

● Brunner Mond's £10 million new sodium bicarbonate manufacturing facility in Cheshire.

The chemistry-dependent upstream industry has also made a positive contribution to UK trade performance over many years. This is shown by a trade surplus in the upstream industry – the UK's exports from the upstream industry exceed the industry's imports as shown in Figure 2.

Generating vital non-economic benefits that improve quality of life

Products and services derived from chemistry research underpin every aspect of modern life, ranging from plastics used in domestic appliances and car dashboards, polyester used in packaging, clothing, home furnishings and carpets, through to medicines, clean drinking water, sewage disposal, paints, rubber compounds for tyres,

automotive lubricants and even the food we eat. There are a number of case studies in the report that bring to life some of the immeasurable ways in which chemistry improves the quality of lives. For example:

● fire resistant glass – one of the most chemistry-intensive products marketed by Pilkington, it reduces both the human and economic cost of fire by reducing the speed at which a fire/smoke can spread;

● Azoxystrobin – an extremely successful agricultural fungicide developed by UK-based chemists between 1981 and 1996, it is now used to increase yields of more than 120 crop types in over 100 countries;

● healthier foods – chemists have developed foods with a lower fat or salt content whilst maintaining the taste, texture or performance of the product;

● Amlodipine – a drug discovered at Pfizer, it is used to treat hypertension and angina and is shown to have reduced the number of days a patient visits hospital, reducing costs to patients and the health service.