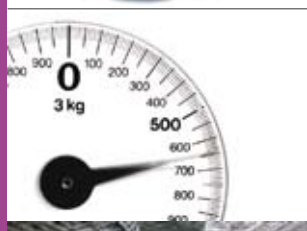
Well dressed?

The present and future sustainability of clothing and textiles in the United Kingdom



Biffaward
Programme on Sustainable Resource Use

Well dressed?

Are we well dressed?

Our clothes are getting cheaper, they follow fashion more rapidly and we're buying more and more of them. At the same time, we hear more about poor working conditions in clothing factories, the greenhouse effect is becoming more threatening and the UK is facing a crisis in disposing of its waste. What should we do?

This report aims to help answer that question, by looking at what might happen if the way that our clothes are made and used were to be changed. What would happen if we used different fibres, or different farming practices? What would be the consequence of washing our clothes in a different way, or keeping our carpets for longer? What would happen if more of our clothes were disposed of through clothes banks?

In the UK we are already awash with information on these questions – so why read this report? Firstly, the report is intended to be neutral – it does not have an agenda, or seek to promote a particular change or approach. Secondly, it attempts to take a very broad view of the sector – encompassing the views of business, government and campaigners and trying to reflect the widest definitions of 'sustainability'. Thirdly, it attempts to identify the potential for significant and lasting change by looking at what might happen if a whole industrial sector were to experience a change.

The report is intended to be valuable to a wide range of interested groups. It is written for people in business – who have to balance their personal ethics and the concerns of their consumers with the need for their business to prosper. It is written for consumers who have a limited budget but are concerned about the impact of their shopping choices. It is written for campaigners and those in education, government and the media – to try to provide as balanced evidence as possible about the present and future impacts of the clothing and textiles sector.

Five person-years of work leading to this report were funded by the Landfill Tax Credit scheme, through the Biffaward scheme administered by the Royal Society of Wildlife Trusts and with 10% funding from Marks and Spencer. On the way to writing the report, we have received help from hundreds of people working in the sector and have attempted to acknowledge many of them inside the back cover. We would particularly like to acknowledge the contributions of Marisa de Brito, who worked with us for the first half of the project, Jon Cullen who designed the graphics, sourced the photographs and edited and laid out the document, and our steering committee of Mike Barry from Marks and Spencer, Peter Jones from Biffa and David Aeron-Thomas from Forum for the Future.

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Executive Summary

In 2000 the world's consumers spent around US$1 trillion worldwide buying clothes. Around one third of sales were in Western Europe, one third in North America and one quarter in Asia.

- Today, clothing and textiles represent about seven per cent of world exports.
- Globally, the workforce in clothing and textiles production was around 26.5 million in 2000.
- More than a quarter of the world's production of clothing and textiles is in China, which has a fast growing internal market and the largest share of world trade. Western countries are still important exporters of clothing and textiles, particularly Germany and Italy in clothing and the USA in textiles.
- Output from the sector is growing in volume, but prices are dropping, as is employment, as new technology and vertically integrated structures support improved productivity.
- Growth in volumes is almost entirely associated with polyester – volumes of natural fibre production and use having remained approximately constant for several years.
- The sector is freer than for many years following the phasing out of international quota agreements in 2005, but plenty of agreements that distort the free-market still exist – with USA government subsidies of cotton farmers being prominent.

The **major environmental impacts** of the sector arise from the use of energy and toxic chemicals:

- The sector's contribution to climate change is dominated by the requirement for burning fossil fuel to create electricity for heating water and air in laundering. Other major energy uses arise in providing fuel for agricultural machinery and electricity for production.
- Toxic chemicals are used widely in cotton agriculture and in many manufacturing stages such as pre-treatment, dyeing and printing.
- Waste volumes from the sector are high and growing in the UK with the advent of 'fast fashion'. On average, UK consumers send 30kg of clothing and textiles per capita to landfill each year.
- Water consumption – especially the extensive use of water in cotton crop cultivation – can also be a major environmental issue as seen dramatically in the Aral Sea region.

Social concern has always been a feature of the sector – and campaigns for improved social conditions for low paid workers in developing countries have been effective and continue:

- UK based retailers are increasingly specifying codes of good practice in labour standards to their suppliers, but there are difficulties in imposing these throughout the supply chain, leading to concerns about working hours, safety and use of child labour.
- Most countries in the supply chain have a legal minimum wage, but in some cases this is lower than a realistic minimum living wage – so while the sector offers an opportunity for development by creating many relatively low skilled jobs, some workers are unable to escape from a cycle of poverty.
- In some countries the right of workers in the sector to form associations (unions) to represent their concerns in collective bargaining is suppressed.

The flow of material through the UK: As part of the work described in this report, a clothing and textiles mass balance for the sector was calculated for the UK.

- 3.25 million tonnes of clothing and textiles flow through the UK each year – approximately 55kg per person.
- Of this, around half is imported as textile products, a quarter as 'intermediate products' (mainly fabric and yarn) and the rest as fibre (imported or produced in the UK). Approximately two thirds of the imports of fibres, yarns and fabrics to the UK are man-made.
- The UK exports 1.15 million tonnes of clothing and textiles each year, comprising fibres, fabric and some completed products – mainly clothing and carpets.
- One fifth of the UK's annual consumption (by weight) of clothing and textile products is manufactured in the UK.
- Consumers in the UK spend about £780 per head per year, purchasing around 2.15 million tonnes (35kg per person) of which one eighth is sent for re-use through charities and the rest is discarded.
- The UK clothing and textile industry employed around 182,000 people in 2004 split evenly between clothing and textiles.

The future of the sector: in order to anticipate likely trends in the sector, we conducted a structured 'Delphi' study, gathering information from a panel of experts across the sector. Their major predictions are:

- Competition in the sector will increase, as skill levels and investment in developing countries continues to grow. Prices in the UK will continue to be driven down.

- Innovations may include new production technologies to reduce the labour requirement of garment completion and development of novel 'smart' functions.
- Pressure from consumers and legislation is likely to drive increasing demands for environmentally sensitive production. In the short term this is likely to focus on the use of chemicals but may extend to include re-use of materials and substitution of alternative materials.
- International campaigns will continue to drive improvement in working conditions for employees in developing countries.

Developing a more sustainable future: the largest part of the work for this report was a wide-ranging scenario analysis of various possible futures. The analysis included prediction of the environmental, economic and social consequences of changes in production structure, consumer behaviour, material and process innovations and government influence. The main findings of the scenario analysis are:

- Improvement in the environmental performance of the sector is material specific and depends on the energy and toxicity life-cycle profile of the material. For conventional cotton products, the requirement for energy is driven by laundry, but the use of toxic chemicals is driven by agriculture. In contrast, for viscose, energy use is dominated by production.
- For products in which production dominates impacts, process efficiencies should be pursued and the impact will be reduced by extending the life of the product or by re-using materials by some form of recycling.
- For products in which raw material production dominates, in addition to measures to extend product life, alternative processes or materials should be pursued. A switch from conventional to organic cotton growing would eliminate most toxic releases, at the cost of price rises in the UK.
- Energy requirements for cotton garments are dominated by washing, drying and ironing. In response, wash temperatures can be reduced and tumble drying avoided. Novel treatments may provide resistance to odours so reducing the total number of washes or allow faster drying with less ironing.
- The UK's current behaviour in disposing of used clothing and textiles to landfill is not sustainable as volumes are growing. Incineration is preferable to landfill, as it allows energy recovery and reduces final waste volumes.
- The second-hand sector is growing and there is further demand, so improved collection and sorting procedures will be beneficial in reducing waste and providing useable clothes to developing countries.
- Recycling is significant for materials with high impacts in the production phase. Technology innovations may provide a means to extract longer fibres from used textiles, although a recent innovative business for carpet recycling failed to achieve profitability.
- The globalised structure of the clothing and textile supply chain does not have significant environmental disadvantage, as energy used in transport is proportionately low and the UK does not have a supply of relevant raw materials. Technology innovations such as 3D knitting and weaving may lead to economically viable production in the UK, with some consumer benefits from increased responsiveness. However, this will only have environmental benefits if associated with material recycling.

Change in the sector **to reduce environmental impact and promote social equity** will occur if driven by consumer choice. According to the analysis of the report, in order to create change, a consumer would:

- Buy second-hand clothing and textiles where possible.
- Buy fewer more durable garments and textile products.
- When buying new products, choose those made with least energy and least toxic emissions, made by workers paid a credible living wage with reasonable employment rights and conditions.
- Lease clothes that would otherwise not be worn to the end of their natural life.
- Wash clothes less often, at lower temperatures and using eco-detergents, hang-dry them and avoid ironing where possible.
- Extend the life of clothing and textile products through repair.
- Dispose of used clothing and textiles through recycling businesses who would return them for second-hand sale wherever possible, but otherwise extract and recycle the yarn or fibres.

Several barriers inhibit the adoption of this behaviour. In order to overcome these barriers:

- **Consumer education** is vital – to ensure that fact based information on the specific impacts of a product are available and understood.
- Increased emphasis on **durability as a component of fashion** would support a move

towards reduced material flow.

- The sector could halve its material flow without economic loss if consumers **pay a higher price for a product that lasts twice as long.**
- **New business models** with growth in profit decoupled from increased material flow are possible where consumers pay for services – such as repair, novel coatings, other maintenance services, remanufacturing or 'fashion upgrades'.
- **Technology development** may lead to new means to freshen clothes without washing, efficient sorting of used clothing, new fibre recycling technology and new low temperature detergents.
- The **infrastructure of clothing collection** could be improved.
- **UK government policy** on the environment should be changed to promote reduction of total or embedded impacts in products, not just those arising in the UK.
- The UK's involvement in negotiating **international agreements on trade** could be used to promote environmental and social responsibility.

BIFFAWARD PROGRAMME ON SUSTAINABLE RESOURCE USE

Objectives

This report forms part of the Biffaward Programme on Sustainable Resource Use. The aim of the programme is to provide accessible, well-researched information about the flows of different resources through the UK economy based either singly, or on a combination of regions, material streams or industry sectors.

Background

Information about material resource flows through the UK economy is of fundamental importance to the cost-effective management of resource flows, especially at the stage when the resources become 'waste'.

In order to maximise the programme's full potential, data has been generated and classified in ways that are both consistent with each other, and with methodologies of the other generators of resource flow / waste management data.

In addition to the projects having their own means of dissemination to their own constituencies, their data and information has been gathered in a common format to facilitate policy making at corporate, regional and national levels.

More than 60 different mass balance projects have been funded by Biffaward. For more information, please visit www.massbalance.org

Contents

The world of clothing and textiles

Introducing the way that clothes and textiles are produced at present and understanding the economic, environmental and social significance of the sector.

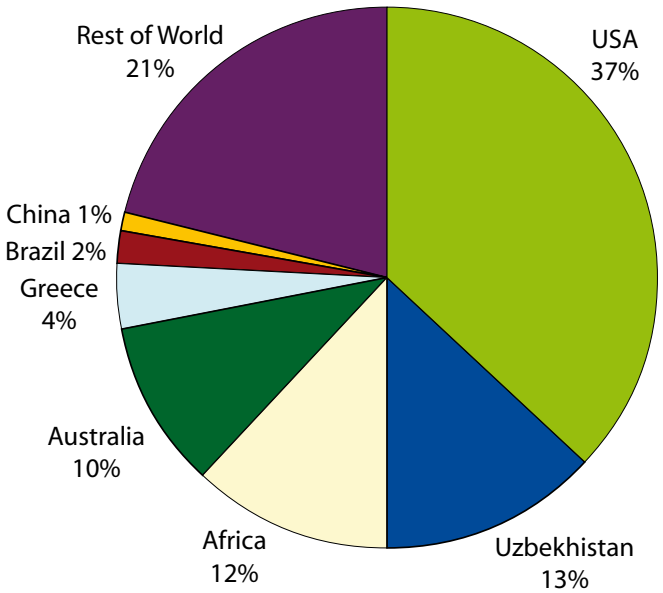
The world of clothing and textiles

We start this report by giving an account of the clothing and textiles sector as it is now. The next section reports on the flow of materials through the UK associated with clothing and textiles, to provide a macro-economic materials account of the sector. The remainder of the report presents a structured 'scenario analysis' in which we present various possible changes to the way we make and use clothing and textile products and explore how these might lead to a more sustainable future.

The clothing and textiles sector is a major part of world trade

The clothing and textiles sector is a significant part of the world's economy. In 2000 the world's consumers spent around US$1 trillion on clothing – split roughly one third in Western Europe, one third in North America, one quarter in Asia [A1]. Seven per cent of total world exports are in clothing and textiles. Significant parts of the sector are dominated by developing countries, particularly in Asia, and above all by China. Industrialised countries are still important exporters of clothing and textiles, especially Germany, Italy in clothing and the United States in textiles. Developing countries now account for half of the world textile exports and almost three quarters of world clothing exports. However, for some materials, processes or products, other countries have an important role. The figure shows how the USA remains the largest world exporter of cotton, despite having only 25,000 cotton farmers. Australia and New Zealand are the largest suppliers of wool and of carpets – which can be made with efficient machines requiring little manual labour – many countries including the UK are able to serve a significant fraction of their own demand.

World cotton exports 2001/2



Source: ICAC 2001

Rapid change in international trade agreements

Because of the size of the sector and the historical dependence of clothing manufacture on cheap labour, the clothing and textile industry is subject to intense political interest and has been significantly shaped by international trading agreements. From 1974 to 2005, as the skills and infrastructure of Chinese manufacturing developed while retaining an advantageously low wage rate, a series of 'quotas' and tariffs were imposed by developed economies especially on Chinese exports, to attempt to protect their own manufacturing interests. These agreements (which will be discussed in more detail later in the report) were officially ended on 1 January 2005, but the rules of trade remain complicated and continue to change rapidly. Regional trade blocs and preferential trade agreements maintain various distortions to 'free trade' but the ending of the main set of quotas has led to a rapid rise in Chinese exports and a consequent drop in prices for UK consumers. Negotiations over China's accession to the WTO continue to give some protection to those threatened by Chinese growth until 2008. During the period in which quotas were phased out, from 1980 to 2000, average tariffs fell from 10% to 5% in developed countries and 25% to 13% in developing. Within developing countries, such as China, there is a proliferation of Export Processing Zones, where some preferential treatment by the domestic government facilitates strong exports.

Market distortion from subsidies remains

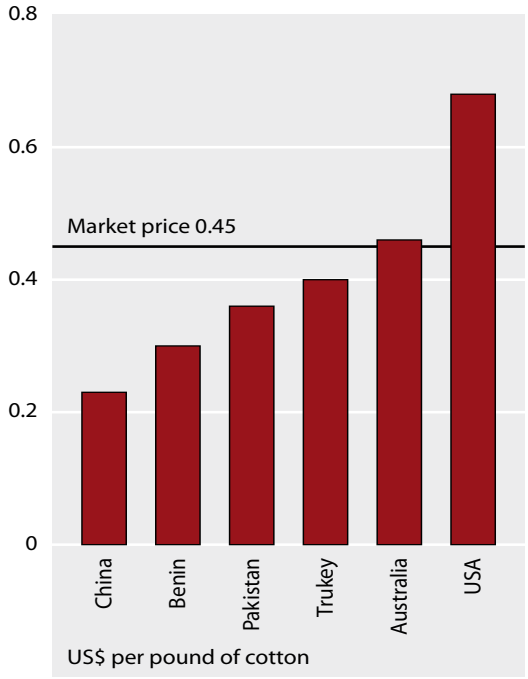
In addition to protection from low labour cost countries by imposition of quotas and import tariffs, exporting countries have also supported their manufacturing industries through allocation of subsidies [A2]. The figure shows estimates of the true cost of producing a pound (weight) of cotton in 2001 – at a time when the market price was around US$0.45 per pound. USA costs were highest, but subsidies provided by the USA government brought down the price artificially – creating grave difficulties for developing countries, for whom cotton could be a significant fraction of total exports. The USA is the second largest producer of cotton in the World and the largest exporter – and accounts for half of worlds' production subsidies.

Over 26 million people work to produce clothing and textiles

Estimating the number of people working in these sectors is extremely difficult, due to the number of small firms and subcontractors active in the area and the difficulty of drawing boundaries between

sectors. According to the current (2006) statistics of the UNIDO (United Nationals Industrial Development Organisation) Industrial Statistics Database (INDSTAT) around 26.5 million people work within the clothing and textiles sector worldwide [A3]. The data base contains the most recent estimates of employment within each country, typically using data between 1998 and 2002 – so more recent studies (for instance a 2005 ILO report [A4]) quote different figures, with

Market and producer prices for cotton 2000/01

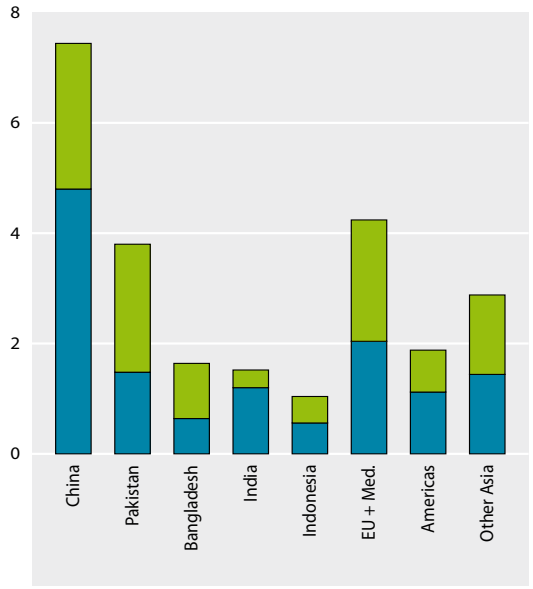


Source: ICAC, Survey of the cost of production of raw cotton, 2001

estimates of employment in China as high as 19 million. Of these 26.5 million employees, 13 million are employed in the clothing sector and 13.5 million in the textiles sector [A3]. These figures are only people employed in manufacturing – not retail or other supporting sectors. Thirty six countries employ more than 100,000 people in the sector, of which China (at 7.5 million employees) is clearly dominant. Four other countries employ more than one million people and 30 of the remaining 31 countries are grouped into three regions and shown in the figure. South Africa is excluded, as it doesn't fit the geographical grouping, and data for other sub-Saharan African countries are uncertain, but estimates of employment in French speaking Africa are as high as two million. (The INDSTAT database contains no figures for Pakistan and the estimates given here are taken from an ILO report.)

Brazil, the Russian Federation, the USA, Vietnam, Italy and Japan all employ more than half a million people in manufacturing in the clothing and textiles sector. The distribution of employment between clothing and textiles varies by country, but generally countries with

Employment in clothing and textiles by country



Source: UNIDO INDSTAT database 2006

higher labour costs tend to have more employment in textiles.

The ILO estimates that employment in the sector fell from 34.2 million in 1990 to 26.5 million in 2000 – a decline of around 20% [A3]. However, these losses were unevenly distributed – with rapid decline of the sector in the USA and EU but growth in several Asian countries. Direct employment in both sectors leads indirectly to further employment – in services and associated industries and by the 'multiplier effect' – as those earning in this sector will spend their earnings on other goods.

Around 70% of clothing workers are women [A5]. In the garment industry, women typically sew, finish and pack clothes. Supervisors, machine operators and technicians tend to be men – who earn more. Conditions for workers vary. Employment opportunities have generally been concentrated at the bottom of the supply chain, in the lower range of qualifications and, very often, in countries with limited alternative job opportunities. These factors have contributed towards maintaining wages in these sectors at relatively low rates.

In some areas – such as Export Processing Zones around the world – credible work policies prevail. However there are still millions of people at the end of the supply chains employed precariously. A box story in a later section of this report describes particular conditions in Bangladesh, where the clothing sector accounts for more than 70% of their total exports.

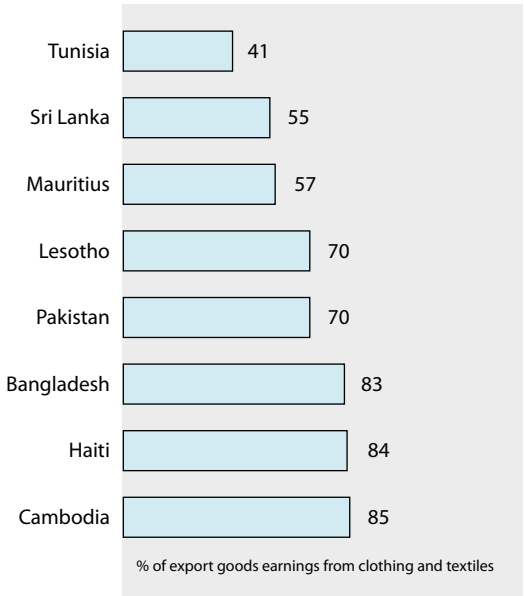
The sector is increasingly dominated by Asian countries

In the past five to ten years, employment in the sector has increasingly been concentrated in China, Pakistan, Bangladesh, India, Mexico, Romania, Cambodia and Turkey. All of these countries, apart from India, have shown increases in clothing and textile employment from 1997 to 2002 – the global decline in employment in the sector is equally marked in countries such as the USA, Europe and the Philippines. Employment in the clothing and textile sector in EU25 countries fell by one million to 2.7 million from 1995 to 2005. A further one million job losses in the sector are anticipated in the next five years.

However, for many smaller developing countries, which are small exporters on a global scale, clothing and textiles exports are their dominant form of external earnings. In Bangladesh, Haiti and Cambodia clothing and textiles account for more than 80% of total exports. Similar high figures apply to the proportion of the country's manufacturing workers employed within the clothing and textiles sector.

The figure below shows typical earnings in the clothing sector in different countries. Strikingly, wage rates in India, Sri Lanka and Pakistan are lower than in China. However, China continues to dominate the sector because of a build up of competitive advantages including short lead times, efficient logistics, a more experienced and skilled labour force, a better power infrastructure (with fewer power outages) and more investment in capital equipment.

Economies where clothing and textiles account for a significant part of exports earnings from the export of goods in 2003



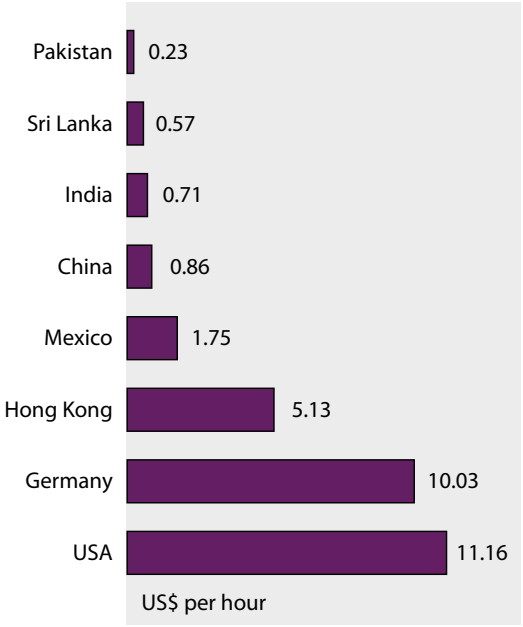
Source: UNCTAD

India is the second largest exporter of textiles, but various analysts have referred to the need to modernise textile machinery in India before businesses in the sector can compete effectively with those in China.

Developing countries account for almost three quarters of world clothing exports and for half of world textile exports. Many Asian garment investors drawn by the African Growth and Opportunity Act (AGOA), a preferential trade agreement signed with the USA, have set up garment factories in Kenya, Lesotho and Swaziland. However, Africa has seen the worst job losses since the end of the Agreement of Textiles and Clothing (ATC).

Despite the dominance of the Asian countries, around six million people are employed in the European and Mediterranean area. Mainly this is due to the trade-off between low labour costs (Asia) and proximity to developed markets (European-Mediterranean) and companies such as Inditex have developed new models for clothing supply based on rapid response to changes in fashion with clothing sourced near to purchase. In Bulgaria the clothing and textiles industry, which has a history spanning two centuries, retains a competitive advantage over neighbouring countries through cheaper labour [A6]. However, this advantage may be eroded once Bulgaria joins the EU, as imposition of EU rules on employment and trade may increase costs as has happened in Hungary and Poland. Bulgaria is also likely to see an increase in imports of cheaper Chinese apparel and textiles as has occurred in Romania since the phasing out of quotas.

Hourly wages in clothing industry



Source: ILO 2003

The sector is becoming more integrated

Setup and switch-over times and costs have traditionally led to large batch manufacture of clothing with long lead times – fashion shows for summer clothing are held in the autumn to allow six months for manufacture. However, this pattern is rapidly changing – with customer demand for so called "fast fashion" where stores change the designs on show every few weeks, rather than twice per year. This emphasis on speeding up production has led to concentration in the industry with fewer larger suppliers – to take advantage of economies of scale (for instance in purchasing) and to simplify the number of relationships that must be maintained by retailers.

This trend is now more noticeable in the clothing sector with the growth of 'full package' companies that are able to supply quick time delivery orders to big retailers. Downstream textile finishing and dyeing processes are being integrated into textile weaving factories and further integrated with clothing manufacture and the distribution networks. Such integration supports rapid servicing of the demand for 'fast fashion' by avoiding the build up of stock characteristic of long supply chains and providing shorter lead times. There is also a trend towards investing in increased capacity and introducing "new industrial robotics" – substituting expensive labour with novel technologies. A variant of such single company vertical integration also in evidence is the development of clusters of businesses supporting each other through Regional Integration [A7].

Despite rising fuel prices, distribution costs throughout the sector are dropping, as logistics companies become more efficient at managing the flow of goods across wide distances.

UK production is increasingly focused on niche products

The UK had a dominant role in the clothing and textiles sector in the early 19th Century but has seen a steady decline – with a symbolic withdrawal of Marks and Spencers' demand from UK clothing and textile manufacturers in the 1990's. Activity in the sector in the UK is now focused on design more than production – but potentially the UK may also serve as a source of innovation, particularly for niche or high quality products. An example of this is the UK's strength in wool production which has traditionally been recognised for delivering state of the art goods to international market such as Japan and the USA. The UK is also developing competitiveness in novel 'nanotechnology' coatings and smart functions to be applied to clothing and textiles and in the design and manufacture of technical textiles [A8], such as those for protective clothing and medical use.

Despite the exit of manufacturing in clothing and textiles from the UK, the sector continues to be highly valuable, as the biggest profits in the sector are at the end of the supply chain – in retail and branding. The cost and price structure of the sector globally is now characterised by there being the potential for high profit from innovation, marketing and retailing but low profit from sourcing, production, assembly, finishing, packaging and distribution.

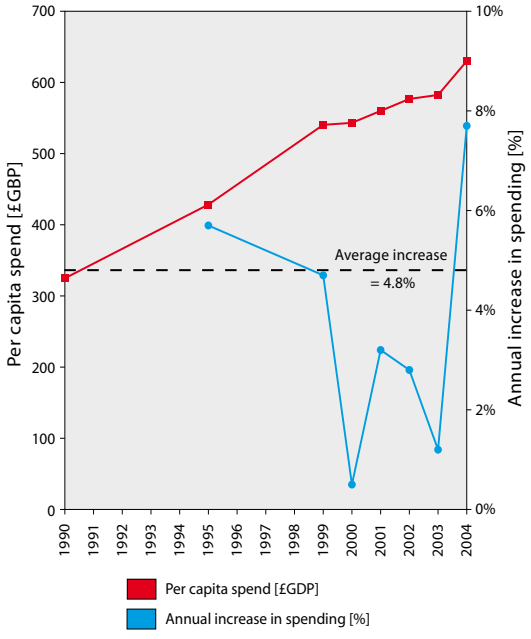
In supplying finished goods to end consumers, multiple store retailers dominate this sector – selling 70% of clothing in Western Europe and 85% in the USA. The top five department stores in the USA delivered about half of its total sales [A9].

Consumers are accustomed to increasing variety at low prices

In the UK in 2004 we spent on average £780 per head on clothing and textiles, of which around £625 was on clothes. Total spending on clothes in the UK in 2005 was £38.4 billion of which £24 billion was on women's, girls and infants clothing, £12 billion on men's and boys' clothing and £2.4 billion on accessories, hire, cleaning, tailoring, etc.

From 2001 to 2005 spending on women's clothing grew by 21% and that on men's by 14%. During the same time – as the end of the quota arrangement approached in 2005 – prices actually dropped by 14%

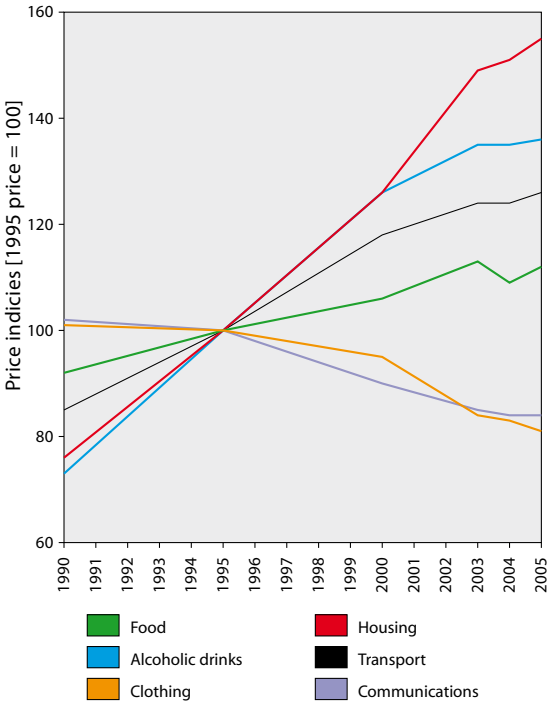
UK retail sales of clothing



Source: ONS

in real terms, so sales by volume increased by 37%. Thus, over four years, the number of garments bought per person in the UK increased by over one third [A10].

Price indices for consumer goods and services



Source: ONS [1995 prices = 100]

Second-hand clothing is worth $1 billion per year

After the consumer use phase the life of a garment or textile product is not over. Some clothes and textiles are taken to recycling clothes banks operated for example by the Salvation Army (which also has door to door collection), Traid, Oxfam, or many other members of the Textile Recycling Association.

The goods are transported to recycling plants to be sorted. The best quality garments are sent for resale at charity shops and a small number of items are re-

manufactured to add value and sold as fashionable items. However, most are baled and shipped for resale in Eastern Europe, the Middle-East or Africa. Second-hand garments bales are sold via a commodity market to traders and then to stall merchants for resale at local markets.

A small fraction of the collected textiles is shredded and converted into wipes or carded and mixed with other fibres to be re-spun into yarn. An example of such a yarn is that developed by Annie Sherburne with 50% recycled 50% virgin wool.

The second-hand clothes trade in developing countries creates some employment [A11] and is an important

source of low cost clothing. The trade is only a small fraction of global trade in clothing (about 0.5% of the total value) but in many African countries it has a significant proportion of the market, up to 30% of the total value of imports and 50% in volume [A10]. This raises a concern that second-hand clothes inhibit the development of local industry. However, at present trade in second-hand clothing is falling as a share of total clothing imports due to the increase of cheap imports from Asia.

Clothes and textiles come from oil or natural fibres

Clothing and textiles products begin as fibres – which are either natural (e.g. cotton, silk, wool), man-made (made from cellulosics, e.g. viscose) or synthetic (oil used to create polymers, e.g. polyester, acrylic and nylon). The figure shows the breakdown of world demand for these two types of fibre over 15 years – showing that demand for natural fibres has been approximately constant, while demand for man-made fibres has nearly doubled [A12]. The second figure shows that within this man-made category, growth has been driven by demand for polyester.

Manufacture of textiles begins with spinning the original fibres, which are relatively short and thin, into yarns. These yarns are converted into fabrics (often flat sheets), by one of two processes: weaving or knitting. The 'flat' fabric must then be formed into a '3D shell' to be useful as clothing.

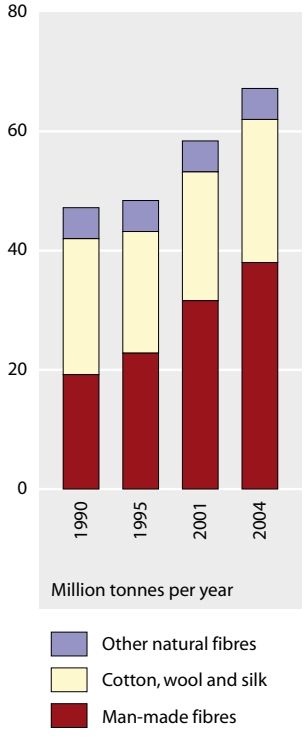
From the design of a garment to the pressing and packaging of a finished product a range of processes are required – each with different requirements for capital, technology and labour: designing, pattern making, grading, nesting and marking, cutting, sewing, quality inspection, pressing and packaging. There is continuous development of technology at all levels of these activities aiming at reduced labour intensity and quicker delivery. However, in 300 years of innovation, no technical substitute has been found for human hands able to handle and sew all kinds of fabrics, a task that is still complex for robots. Instead, the industry has relocated in pursuit of cheap labour (often women) – for whom a low paid job performing repetitive tasks in a factory is more attractive than any of their other options.

However, due to innovations in knitting machines, knitwear is increasingly made by machines – delivering seamless whole garments. Some other production technology innovations include laser cutting of fabric, automated sewing machines that 'learn' operations from humans and ink jet printing of fabric or made-up garments.

Integration of computer aided design and manufacture in the whole supply chain is being developed to reduce lead times and improve the quality and performance of products. Recent research in the industry has aimed to transfer technologies from the automotive industry to use 'new industrial robotics' to reduce the need for expensive labour. This is economically attractive for manufacturers in developed countries with high costs – but potentially will remove important employment opportunities in developing countries.

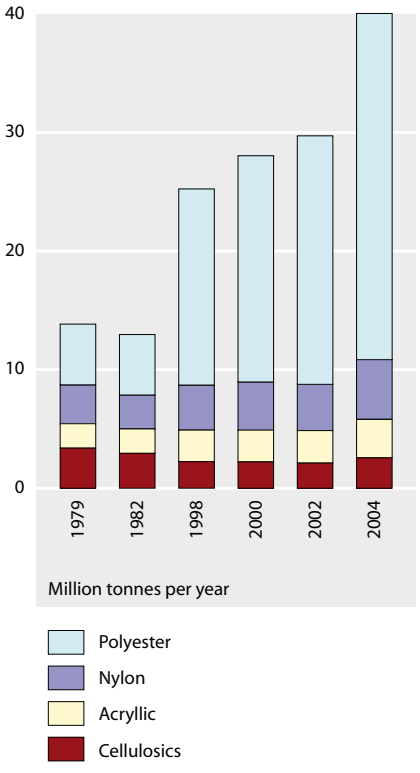
The sector has also seen a rapid adoption of novel IT solutions for production system control and virtual design, stock control, replenishment and real-time monitoring of fashion trends.

World demand for natural and man-made fibres



Source: Textiles Intelligence 2005

Man-made fibre production by type over time



Source: Textiles Intelligence 2003

Major environmental impacts are related to energy use and use of toxic chemicals

Companies face three forms of pressure from their consumers: shareholder expectations, customer loyalty and ethical pressure. There is considerable evidence in the UK that consumer interest in 'ethics' is growing – and so business interest in developing and managing 'Corporate Social Responsibility' is also growing.

The major environmental issues associated with the sector are .

- **Energy use** in laundry, production of primary materials especially man-made fibres and in yarn manufacturing of natural fibres.
- **Use of toxic chemicals** which may harm human health and the environment – in particular in conventional cotton production.[A13]
- **Release of chemicals in waste water** – especially in wet pre-treatment, dyeing, finishing and laundry – which may harm water based life.
- **Solid waste arising** from yarn manufacturing of natural fibres, making up and disposal of products at the end of their life.

Social implications for the clothing and textiles industry

In both sectors there are still many concerns about the quality of the jobs they create and their social consequences.

- Children: even though the elimination of child labour is one of the goals of the International Labour Organisation (ILO) it remains a challenge in the clothing and textiles industry mostly due to the difficulty of monitoring subcontractors, indirect workers and home workers.
- The industry workforce is largely made up of young women, who are "low skilled" or "unskilled" and may be migrants. Such workers are vulnerable to various forms of abuse and may not know or be able to claim their rights as employees[A14]. Some UK retailers are working to impose ethical conditions on their suppliers in an attempt to protect such workers, but the success depends upon rigorous implementation which is costly. A particular problem at present is that many subcontractors deny the right of workers to form an association (or trade union) to assert their rights to appropriate working conditions, pay and training and promotion.
- Pay: most countries supplying the UK's clothing and textiles have a legally defined minimum wage, but social campaigners assert that there is a difference between such a 'minimum legal wage' and a 'minimum living wage' – it may not be possible to escape from a cycle of poverty with only the minimum legal wage.
- Precarious employment: use of repeated temporary contracts or the absence of any employment contracts combined with delayed payment and the absence of employment benefits, is common practice in some countries.
- Sexual harassment: campaigners for women's labour worldwide report cases in which women are threatened by their superiors and unable to complain[A1], without risk of losing their jobs.

The major occupational health issues associated with the sector are exposure to:

- **Hazardous chemicals** particularly in cotton production, wet pre-treatment, dyeing, finishing and making up.
- **Fibre dust**, especially when processing cotton, giving rise to the respiratory disease termed byssinosis.
- **Noise** associated with yarn manufacturing, knitting and weaving.
- **Monotonous repetitive processes** in making up, leading to injuries amongst sewing machinists.

UK clothing and textiles mass balance

In 2004 the total UK consumer expenditure on clothing and textiles amounted to £46 .7 billion (or £780 per capita) of which 80% was spent on clothing and 20% on textiles.

The United Kingdom 2004 clothing and textiles mass balance

The overall mass flow of clothing and textile materials and products (excluding shoes and leather) in the United Kingdom in 2004 is shown in the double-page spread overleaf. The primary data sources used in preparing the figure are:

- Detailed HM Revenue & Customs 2004 trade data by value and quantity covering chapters 50 to 63 in the "Combined Nomenclature" classification system [B1].
- Detailed UK 2004 production data by value and quantity provided by the British Apparel & Textile Confederation (BATC) and using the PRODCOM classification system (PRODucts of the European COMmunity) [B2].

Further details of the methodology and assumptions made in preparing this mass balance are given in the technical annex [B3].

Major material and product mass balance findings

From the flowchart it can be seen that:

- 3.25 million tonnes of textiles flow through the UK each year – approximately 55kg per person.
- Of this, half (52%) is imported as textile products, 25% as 'intermediate products' mainly fabric, yarn and non-wovens. The rest is imported fibre and fibre created in the UK – about 10% each. The total import of textile materials and products is about 2.9 million tonnes.
- The UK exports 1.15 million tonnes of clothing and textiles each year, comprising fibres, fabric and some completed products (mainly clothing and carpets). This includes about 200 thousand tonnes of products for reuse, recycling and final waste disposal abroad.
- The total UK consumption of textile products is approximately 2.15 million tonnes equivalent to approximately 35kg per UK capita. The average consumer expenditure can therefore be estimated to be around £20 per kg.
- The combined waste from clothing and textiles in the UK is about 2.35 million tonnes (0.7% of UK total [B4]), 13% going to material recovery (about 300 thousand tonnes), 13% to incineration and 74% (1.8 million tonnes) to landfill.

The UK clothing and textile sector and industry

Several key indicators and findings for the sector and the industry can be extracted from the figure to the right [B4 B5 B6]:

- About 0.6kg of oil equivalent primary energy is used in the industry per kg of output (about 0.4% of the UK total).
- About two kilograms of CO2 equivalent is emitted to air per kg output (about 0.4% of the UK total).
- Approximately 60kg of water is used (about 0.5% of UK total) and about 45kg of waste water is discharged per kg of output. The difference is lost as evaporation during textile wet processes (e.g. dyeing).
- About one kg of solid waste arises per kg of output (about 0.5% of UK total).
- About half of the UK consumption of products is clothing (about one million tonnes). The major clothing product categories (both by value and mass) are "Trousers (woven) etc.", "Pullovers etc." and "T-shirt etc.". Combined these three clothing categories represent about half of the total consumption by mass.
- One fifth of the UK's annual consumption by weight of clothing and textile products is manufactured in the UK (about 0.4 million tonnes). Of this about one third is carpet alone.
- About two-thirds of the UK import of basic textile materials (fibres, yarns and fabrics) by mass to the industry is man-made, the rest is of natural origin (primarily cotton and wool – about 15% and 10% respectively).
- Total employment in the industry amounted to 182 thousand people in 2004 (47% in textiles and 53% in clothing). This is equivalent to a productivity of about £50 thousand of sales per employee.

Essential inputs and outputs for the UK clothing and textiles industry 2004

INPUTS

Primary energy consumption
989 thousand tonnes of oil equivalent
0.4% of total UK consumption

Water consumption
90 million tonnes
0.5% of total UK consumption

Employment
182 thousand people
47% in textiles, 53% in clothing

Imports of fibres and intermediate products
Total imports: 1,214 thousand tonnes
361 thousand tonnes of fibres
251 thousand tonnes of yarn
325 thousand tonnes of fabric
277 thousand tonnes of intermediate products

Fibres, yarns and fabrics:
29% natural, 60% man-made, 11% unspecified

Imports of clothing and textile products
Total imports: 1,700 thousand tonnes

Total value of clothing: £10,859 million
Trousers: £1,894 million
T-shirts: £1,518 million
Pullovers: £1,021 million

Total value of textiles: £4,657 million
Carpets: £824 million

The UK clothing and textile industry

UK production of clothing and textile products

Total production: 697 thousand tonnes

Total value of clothing: £3,925 million
Trousers: £308 million
Work-wear: £232 million
Pullovers: £214 million

Total value of textiles: £5,657 million
Carpets: £754 million

UK consumption of clothing and textiles

UK consumption of clothing and textile products

Total consumption: 2,156 thousand tonnes
About 50% clothing and 50% textiles

The major products consumed were:
420 thousand tonnes of trousers, T-shirts and pullovers
530 thousand tonnes of carpets

OUTPUTS

Carbon dioxide emissions
3.1 million tonnes of CO_2 equivalent
0.4% of total UK emissions

Waste water
70 million tonnes

Solid waste
1.5 million tonnes
0.5% of total UK waste

Exports of fibres and intermediate products
Total exports: 677 thousand tonnes
215 thousand tonnes of fibres
117 thousand tonnes of yarn
277 thousand tonnes of fabric
68 thousand tonnes of intermediate products

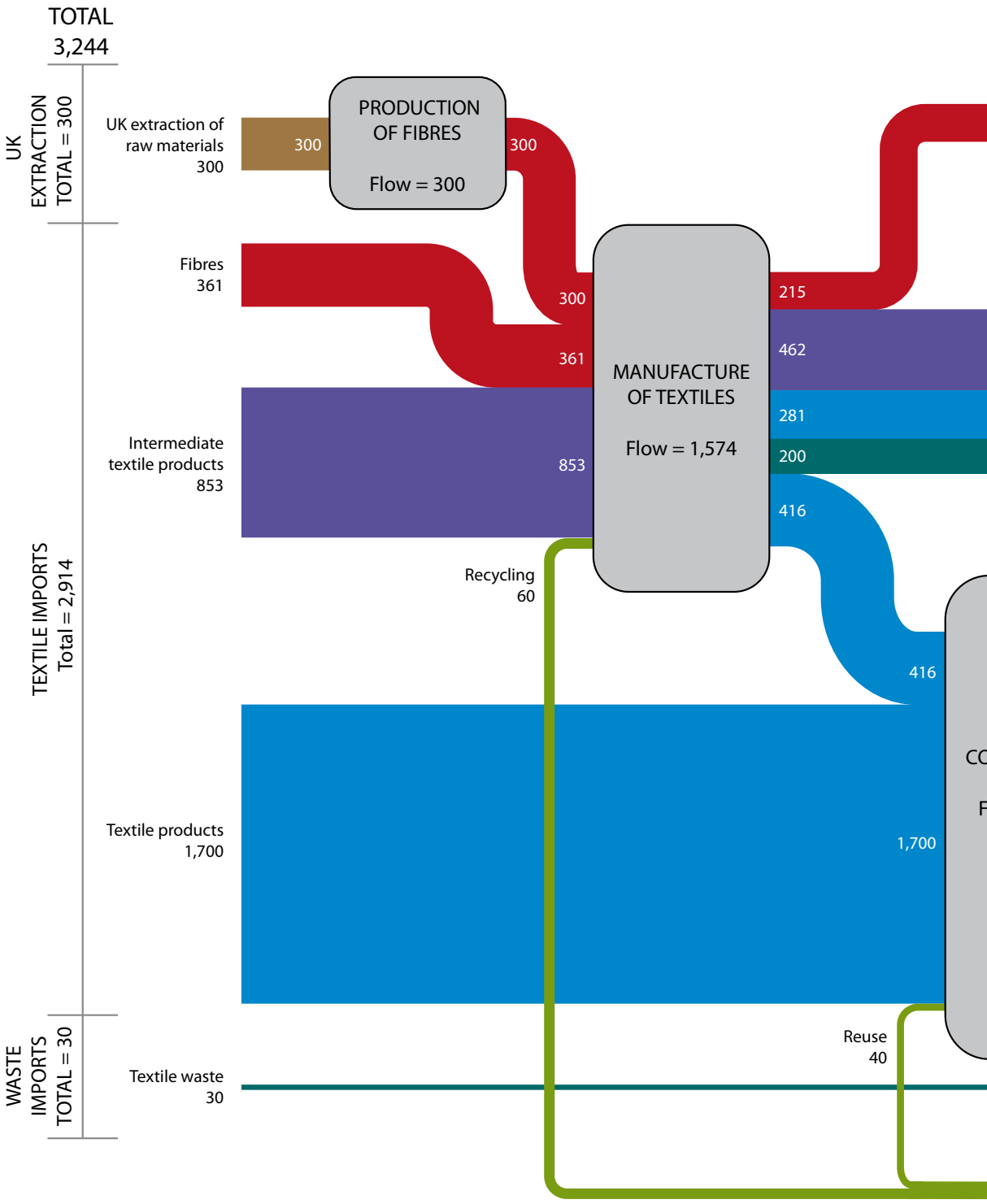
Fibres, yarns and fabrics:
19% natural, 64% man-made, 17% unspecified

Exports of clothing and textile products
Total exports: 281 thousand tonnes

Total value of clothing: £2,719 million
T-shirts: £336 million
Trousers: £322 million
Pullovers: £220 million

Total value of textiles: £3,359 million
Carpets: £205 million

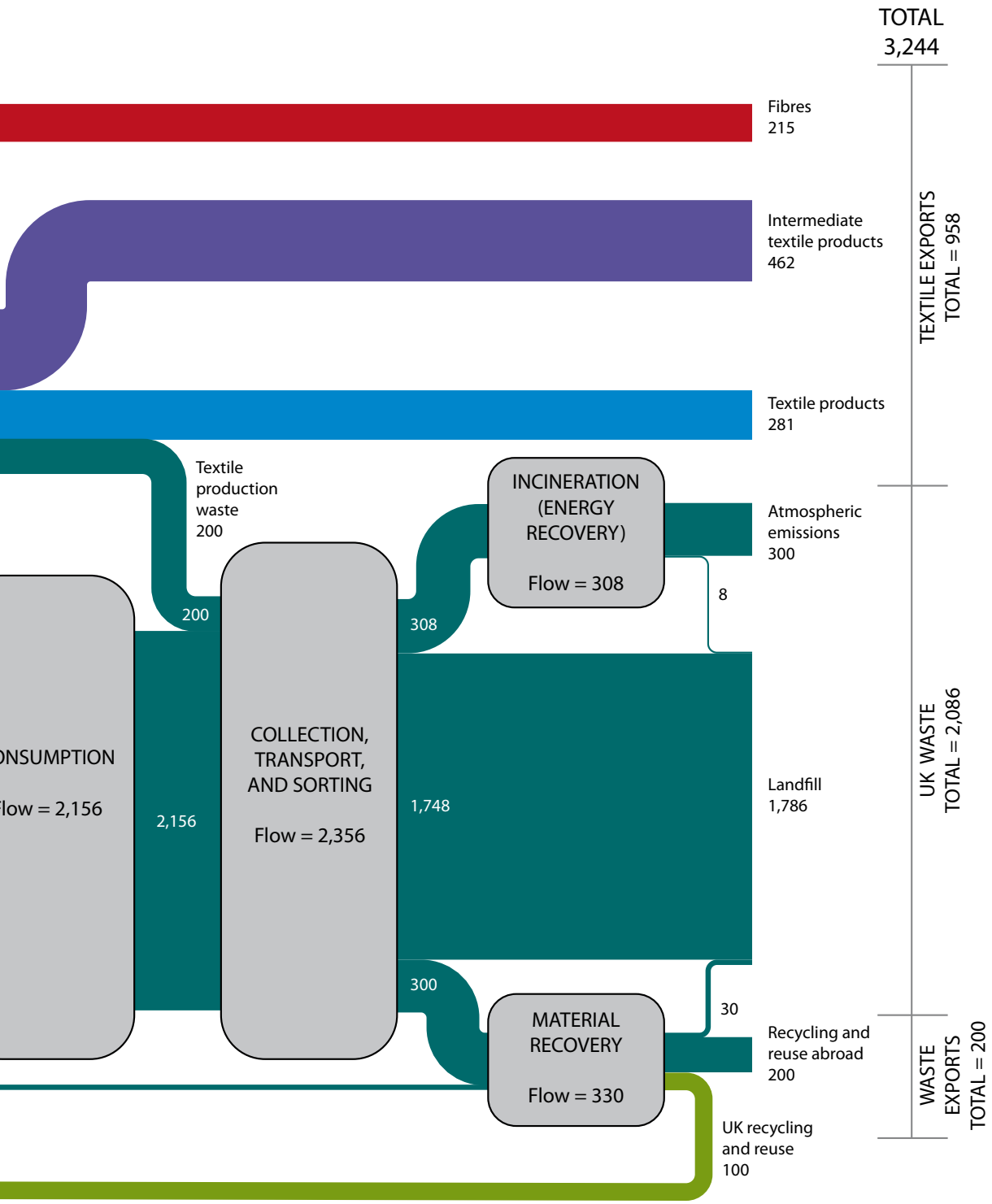
Textile flows in the United Kingdom



Key:

Raw materials
Fibres
Intermediate textile products
Textile products
Waste
Material recovery

Units: Flows [thousand tonnes per year]
(for assumptions and quality of data see technical annex)



Scenario analysis

The scenario analysis looks at three standard products: a T-shirt, a blouse and a carpet. These products are made with contrasting materials, in different countries and using different technologies. What would happen if they were made or used in quite a different way?

How we developed the scenario analyses

The first part of this report has looked at the flow of material through the UK arising from present day demand for clothing and textiles. The second part of the report explores the possibility that the UK's demand could be met in different ways. For instance: what would be the effect of shifting production from China to the UK? what would happen if consumers kept their clothes for longer and washed them less frequently and at lower temperatures? The reason to ask such broad questions is because awareness of various unwanted environmental and social consequences of clothing and textiles production is growing, but there is little agreement on what should be done in response. Many possible changes to particular products or processes have been proposed. But what are the really important changes – what should we do if it really mattered?

The scenarios that follow describe a series of changes to the way the UK's demand is met. We began by creating a map of the influences that have led the sector to its current form, and of the consequences of that form – according to the 'triple bottom line' (economic, environmental and social) measures of sustainability. This map of influences and consequences was found through a 'Delphi study' of stakeholders across the sector and is reported in the next two pages.

The results of the Delphi study were also used to develop a set of possible future scenarios. The scenarios have been grouped into four key themes representing the major changes that might occur in the operation of the sector: changes in the structure of the supply chain – the location and means of production; changes in the design of clothing and textiles products and the materials used; changes in the behaviour of consumers; changes in the influence exerted on the sector by government.

The scenarios were analysed through use of three representative products: a cotton T-shirt, a viscose blouse and a polyamide carpet. The current production and impacts of these products are described in some detail in the 'base case' section. In each scenario the consequences of changing the way that one or more of these products is delivered is explored, and measured according to the 'triple bottom line' of sustainability:

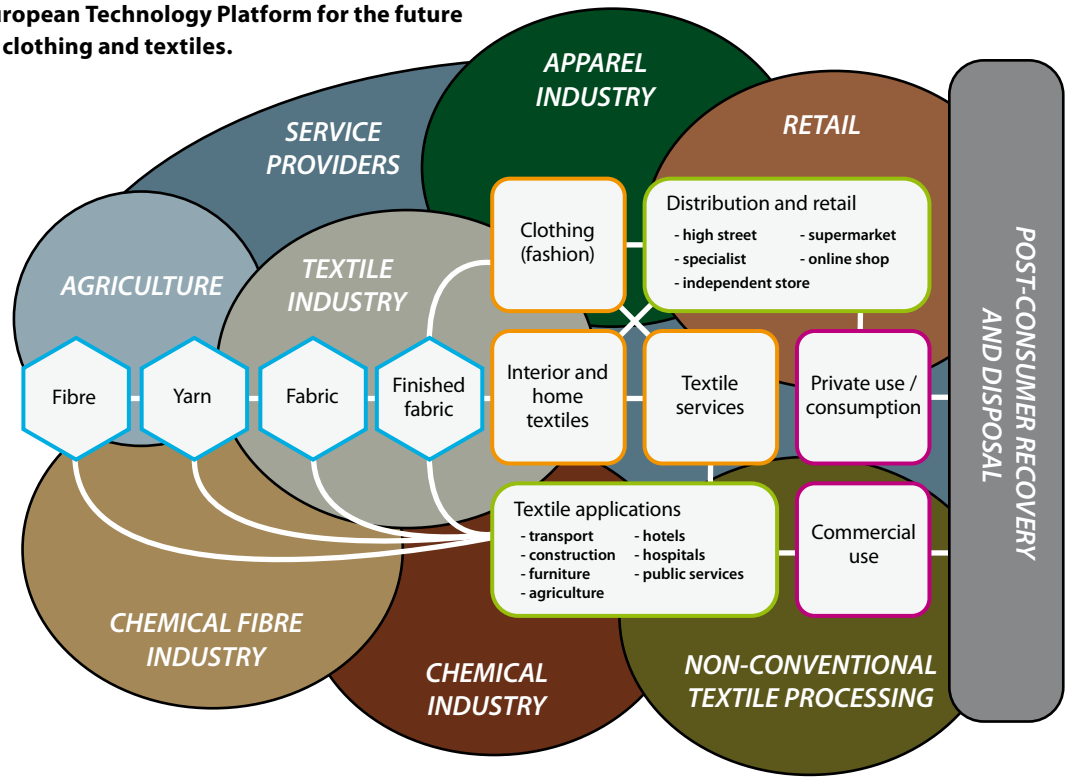
- Economic impact is predicted by a simplified set of national accounts. For each base case product a cost model has been developed, showing raw material prices and the build up of production costs and transfer prices to the complete product. Each scenario leads to some variation in production costs, which leads to adjustment of the transfer prices. The final consumer price is held constant – so that an increase in production costs is reflected in reduced retailer margin. The product costs are then converted to national accounts for each participating country, by calculating the total output and intermediate consumption of the businesses operating within each country. From these figures, a Gross National Income is derived for each country and, in addition for the UK, a Balance of Trade and Operating Surplus is calculated – the latter giving a broad indication of the profitability of the sector.
- Environmental impact is predicted through detailed life cycle analyses, based on the internationally recognised Danish methodology EDIP (Environmental Design of Industrial Products) and with results summarised by three key indicators: climate change (measured in thousand tonnes of CO_2 equivalent); waste volume (in thousand tonnes); an aggregate 'environmental index' representing the combined effect of ozone depletion, acidification (acid rain), nutrient enrichment (algae growth that can cause fish death) and photochemical ozone formation (smog). The aggregated environmental index is measured in 'Person Equivalent Targeted' (PET) units i.e. the impacts are normalised to one persons share and weighted according to political reduction targets. The GaBi-EDIP [C1] software tool was used to calculate and evaluate the environmental impact. The GaBi-EDIP software package includes an input and output database on various unit processes in the life cycle of textile products and can calculate the environmental impact according to several internationally recognised life cycle assessment methodologies. Most of the textile related data in the software tool was developed during the Danish EDIPTEX project [C2].
- Social impact is described qualitatively in two areas: the influence of changes on consumers in the UK; the influence of changes on the social conditions of those involved in production. Quantitatively, published figures on working hours and productivity are used to predict the total number of people employed in each country for each scenario.

In order to validate our predictions in the scenario analysis, a draft of each theme was circulated to key stakeholders across the sector and their comments incorporated into the report before it was finalised.

Understanding the evolution of the sector

Clothing and textiles products sold in the UK today are delivered by a complex network of businesses and technologies, operating across the world. We refer to this network as the 'structure' of the sector. The major

European Technology Platform for the future of clothing and textiles.



Source: Euratex – A vision for 2020, Dec 2004

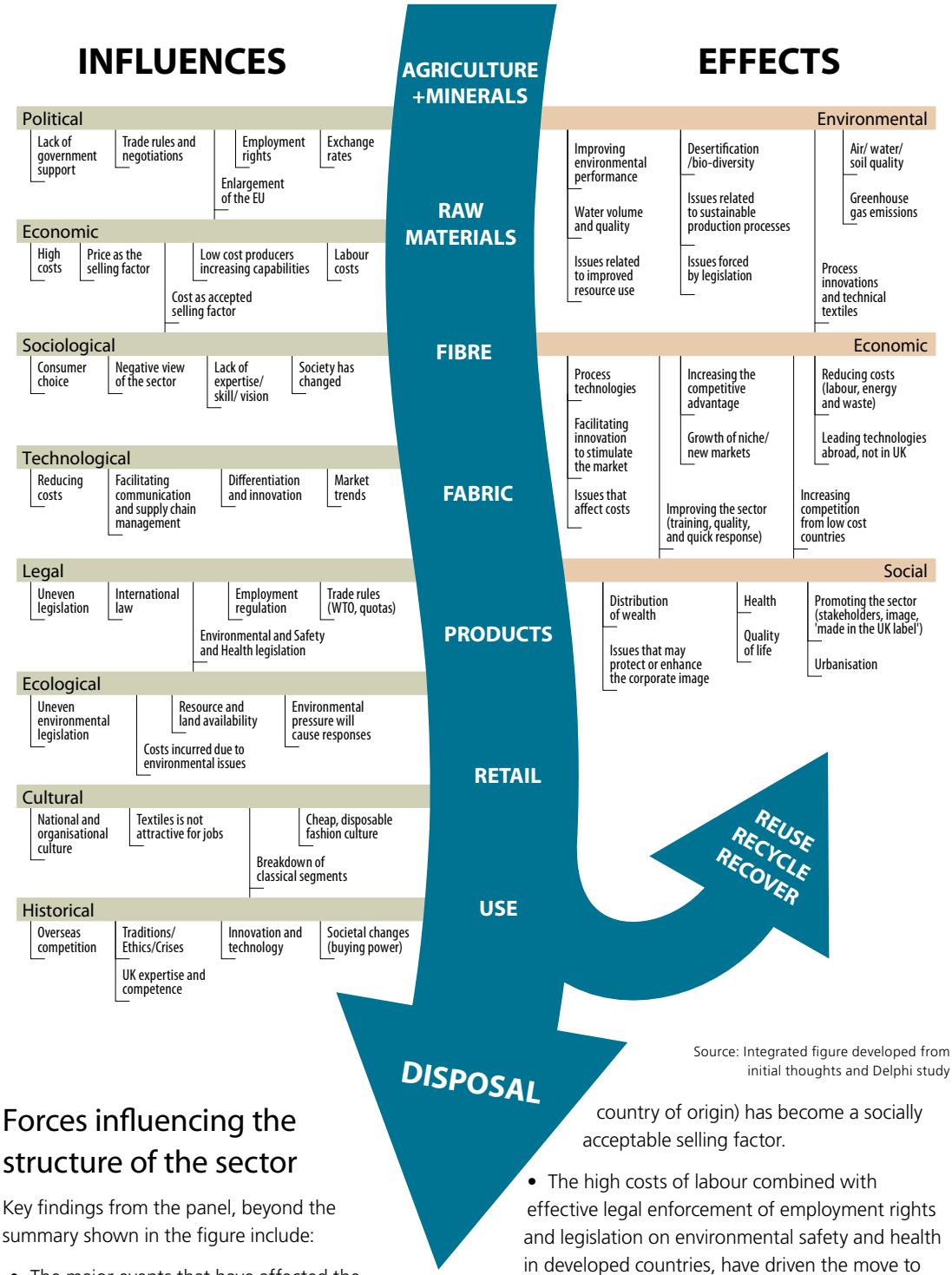
motivation of this report is to examine what would happen if the sector had a different structure: if we were able to promote a change in structure, would this have environmental and social benefits while remaining economically viable?

Before considering changes to the structure, we wanted to find out how the present structure has emerged, and to understand its effects. We began by developing a map of the businesses involved in the sector today which gives an indication of the complex interactions required to bring together the many different raw materials, through the right processes, to create finished products.

The mix of businesses, their current location, size and ownership that deliver clothing and textiles today is the current formation of a continuous evolution. Prior to the Industrial revolution, most countries would have provided most of their clothing domestically, in small businesses in the home. Mass production of fabric and then clothing began in Lancashire in the UK and has had various different centres around the world – including the East Coast of America and Sri Lanka – on the way to the current configuration dominated by China. This is not the only production structure that could provide clothing today – but has evolved according to a series of influences, largely driven by the need for economic profit. Environmental concerns, for instance, have had little effect on the evolution of the structure – but had they been given priority, we would undoubtedly have evolved a different system.

In order to gain insight into the forces that have shaped the sector, current influences and possible future trends, we conducted a Delphi study. A Delphi study is a structured communication with a group of experts using two questionnaire rounds, of which the second questionnaire contains feedback on the first one. The panel of 24 experts we selected were representative of the businesses in the sector, including suppliers, manufacturers, retailers, the post consumer industry, service providers and independent experts in the UK clothing and textiles industry. In the first round, questions about the history of the supply of clothing and textiles to the UK were posed. Answers from the first round were used to design the second round questions about present and future trends, and to allow ranking of responses to first round questions.

The Delphi panel's comments on the forces influencing the sector and its consequences are summarised in the second figure. The influences are grouped according to the categories of PESTLECH (political, economic, social, technological, legal, environmental, cultural and historical factors) – used in business strategy analysis. The effects of the sector are grouped according to the 'triple bottom line' common in discussions about sustainability.



Source: Integrated figure developed from initial thoughts and Delphi study

Forces influencing the structure of the sector

Key findings from the panel, beyond the summary shown in the figure include:

- The major events that have affected the sector in recent times are the rapid shift into offshore sourcing, the phasing out of trade barriers and the fast growth of the discount sector.
- The major challenges for British manufacturing businesses within the sector over the last 25 years have been growing competition from overseas, the lack of ability to differentiate UK products, a failure to invest in new technologies and the lack of government support in contrast to that in other producing countries. The panel also report a shortage of expertise, skill and vision in promoting the sector in the UK and a change in consumer attitudes such that price (rather than, for instance, country of origin) has become a socially acceptable selling factor.
- The high costs of labour combined with effective legal enforcement of employment rights and legislation on environmental safety and health in developed countries, have driven the move to offshore sourcing. In addition, low cost producers have increased their capabilities, raising their quality standards to the point that price rather than quality or other differentiation, has become the key focus of competition.
- Technologies facilitating communication and supply chain management were stated to be of major influence within the sector in the UK.
- The panel reported a clear move in behaviour by UK consumers towards a culture of cheap, disposable fashion.

What will influence the development of the sector?

The panel's analysis on the effects of the sector focused on the effects likely to influence the sector in the future. Thus, as well as obvious economic measures of success, the panel has, for instance, anticipated that future consumers will be more concerned about the social conditions of workers making products in the sector.

Economically:

- Competition from low cost countries will become more intense, including low cost with increased skill and quality levels.
- UK manufacturers will develop niche products and specialise in tailor-made, customised products. Opportunities for improved competitive advantage in the UK include improving the environmental performance or products, reducing costs, exploiting innovations in technical fibres, developing higher value products and providing new functionality.
- Novel technologies will develop abroad rather than in the UK. Likely innovations include "smart" clothing (for instance with nanotechnology finishes), innovations in fibres and wearable technologies. Several process innovations are likely to occur, including novel non-woven apparel, more precise applications of dyes and the use of robots in production.

The panel anticipate growth in the development of sustainable textiles and technological innovations combined with ecological sensitivity. Companies are expected to focus more on:

- Improving resource usage (water, energy).
- Substituting harmful chemicals used during the production process and in the fabrics themselves.
- Developing environmentally sensitive production techniques, particularly for cotton.
- Increasing the re-use of materials.
- Using materials that are more sustainable and can be reused. Issues related to cotton growing have to be solved and alternative production processes require development.

Environmental concern is expected to be forced by legislation. However, consumers are increasingly aware of the issues of sustainability and are likely to reflect this in their personal image and to relate this to the corporate image of the brand labels they choose.

Working conditions are expected to improve globally under international pressure. Low cost countries are expected to develop products reaching higher ends of the market and to find niches such as in tailor-made, customised products. For UK manufacturers to compete, as well as investment in technology and skills to reduce costs and innovate, they would need to convince customers of the strengths of a more expensive, but better differentiated UK brand.

The choice of scenarios for our analysis

In order to develop our scenario analysis, we used the predictions of the panel to develop a set of scenarios describing how the sector might operate in future. To these, we added one scenario of our own: several organisations promote the idea of 'localisation' as a strategy for increased sustainability, so we chose to examine the possibility that in future the UK's demand for clothing and textiles might be met by localised production in the UK.

We then grouped the scenarios into four themes:

- Supply chain structure – scenarios considering changes in the physical location of production and changes in the flow of materials.
- Consumer influence – scenarios driven by changes in final consumer behaviour.
- New products and material selection – scenarios attempting to anticipate the impact of various innovations identified by the panel.
- Government Influence – in which the influence of international government decisions affecting free trade is considered.

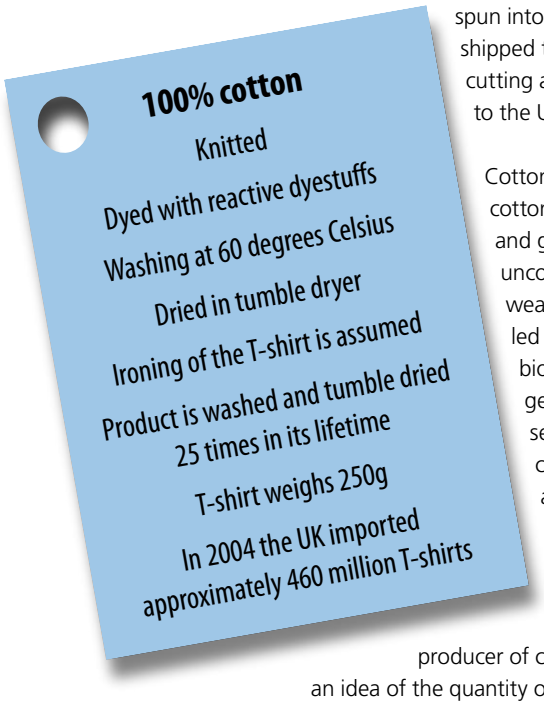
Our analysis of these follows in the next sections, but first we describe the case study products we have considered.

Three case study products

The scenario analysis looks at three standard products: a T-shirt, a blouse and a carpet. These products are made with contrasting materials, in different countries and using different technologies. As a starting point for our analysis, information on prices has been collected from retailers and market surveys, the flow of material from 'cradle to grave' has been mapped, the social conditions of workers in each country have been reviewed and a life-cycle assessment of the environmental impacts of each product has been completed. We refer to the way the case study products are made at present as the "base case".

T-shirt

UK consumers buy around eight T-shirts per person each year. The T-shirt used in our analysis is made of single jersey combed cotton. We assume that the cotton is harvested, ginned and spun into yarn in the USA. The yarn is shipped to China for knitting, dyeing, cutting and sewing, and then shipped to the UK for retail, use and disposal.



Cotton farming can be risky since cotton is vulnerable to disease and growth is dependent on uncontrollable factors like the weather. In the USA, this has led to investment in advanced biotechnologies, including genetically modified (GM) seeds, intensive use of chemicals and a high degree of automation. This has allowed USA cotton farmers to overcome the disadvantage of high labour costs and at present the USA is the largest producer of cotton in the world. To give an idea of the quantity of cotton produced in the USA yearly, if all cotton produced in the USA annually was used in making a single product, it would create more than three billion pairs of jeans or more than 13 billion men's dress shirts. The productivity data for cotton harvesting and spinning are estimated below [C3].

USA Cotton harvesting based on 2005/06 data

Cotton harvested	5.2 million tonnes
Number of people employed in cotton farming	174,000
Kilograms of cotton fibre per employee per year	30,000

USA Spinning yarn based on 2005 data

Spun cotton yarn	1.4 million tonnes
Number of people employed in fibre, yarn and thread mills	54,000
Kilograms of spun yarn per employee per year*	25,000

* assuming the yarns produced were all spun cotton yarns

Cotton crop farmers in the USA are also given additional security through high subsidies distributed by both the government and private institutions as a result of which USA cotton farmers receive higher prices for their cotton than the market price for which it is sold.

In China the clothing and textiles work-force consists mainly of young women. They are often migrants, coming from rural areas, for whom the prospect of a job in a factory (often coupled to living in a factory dormitory) is more attractive than arranged marriage and subsistence living. Official labour law restricts working hours to eight hours per day and to an average of 44 hours per week. However, these rules may be overlooked; working conditions can be hard and some workers may work up to 12 hour shifts seven days a week. In general, the Chinese clothing and textiles labour force is skilled, and coupled with low wages this gives Chinese clothing manufacturers a significant global advantage [C4]. For Chinese T-shirt manufacture (mainly cutting and sewing), productivity is around 15 pieces per worker per day [C5].

Chinese productivity for T-shirts

Number of T-shirts*	460 million
Productivity per employee per day (number of T-shirts)	15
Productivity per employee per year† (number of T-shirts)	4,500

* Based on UK imports in 2004.
† Based on 50 working weeks per year, six days per week.

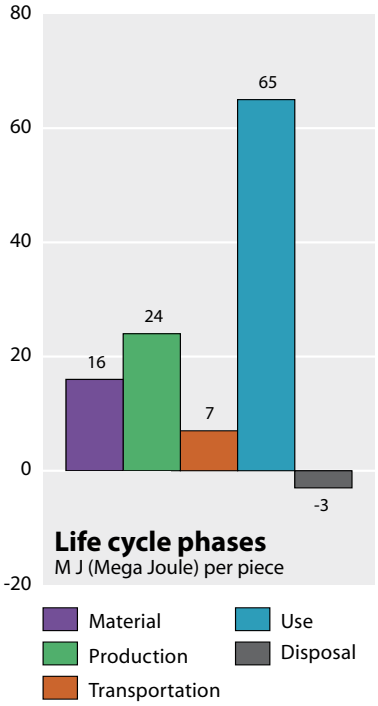
The finished T-shirts from China are shipped to UK wholesalers, from which they are distributed to retailers. In 2004, the UK imported 460 million T-shirts, valued at around £3.2 billion. To meet this demand 150,000 tonnes of cotton fibres were needed to produce yarn in the USA. In China 126,000 tonnes of fabrics were knitted from USA yarn. This fabric would have been bleached, washed, dyed and finished before being cut and sewn to create 115,000 tonnes of T-shirts (i.e. about 25% cotton waste arises in production). In total, 4.2 billion tonne-kilometres of freight were required to meet UK demand for T-shirts, equivalent to sending one kilogram of goods approximately 105 million times around the world!

Primary energy profile

The graph shows the energy profile for the T-shirt, illustrating the consumption of primary energy in the four major phases in the life cycle. The total energy consumption is approximately 109MJ per T-shirt. The breakdown of energy shows that transportation, material, production and disposal phases are dwarfed by the use phase. The use phase includes 25 washes at 60°C, followed by tumble drying and ironing requiring 60% of the total energy. The disposal phase includes incineration in which heat is generated and used so the net energy consumption is negative in this phase.

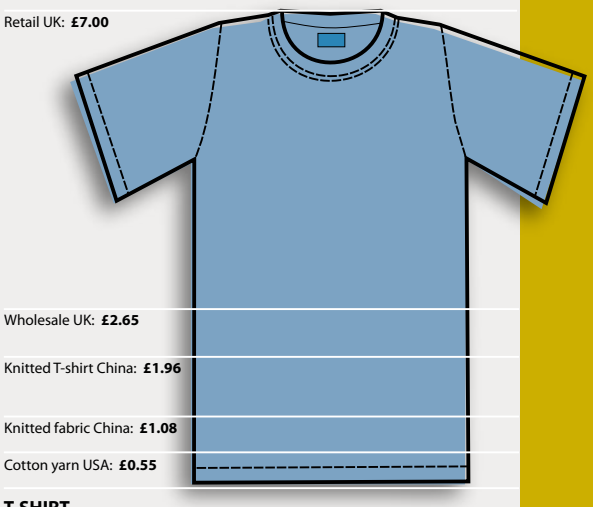
Further details on the assumptions made and a discussion of the consequences are given in the technical annex.

Primary energy profile for the T-shirt



PRICE STRUCTURE OF THE CASE STUDY PRODUCTS

The three graphics show the final price of the T-shirt, Blouse and Carpet paid by consumers in the UK. The lines illustrate 'intermediate' prices paid by one business to another at earlier stages of production. The price is approximately doubled for each progressive stage and the difference between selling and buying prices for a particular business is an estimate of the 'gross profit' of that business. Perhaps surprisingly, even though most production occurs outside the UK, the largest gross profit is for the retailer – reflecting the high costs of operating in the UK.



T-SHIRT

CARPET

BLOUSE

Blouse

Our first product, the T-shirt was made from knitted cotton – an intensively farmed natural fibre. In contrast, the second product used in the analysis is a woven blouse, made from man-made (viscose) fibres. This is an example of a garment bought as a fashion item rather than a basic item. The blouse is produced in India and shipped to the UK. Viscose is an example of a regenerated (man-made) fibre made out of cellulose. In India, production of man-made fibres has almost trebled between 1990 and 2001 and is expected to rise to 2.9 million tonnes in 2010. Viscose accounts for about 11% of total man-made fibre production [C6].

100% viscose

Woven

Viscose is dyed with reactive dyestuffs

Washing at 40 degrees Celsius

Hang-drying

Ironing not necessary

25 washes per lifetime

The blouse is assumed to weigh 200g

UK 2004 imports are approximately 32.5 million pieces

In the Indian clothing and textiles industry, labour accounts for around seven per cent of total costs. A normal working week is 48 hours over six days and India has restrictions on firms' freedom to hire and fire workers. Labour market legislation encourages the existence of small enterprises since the restrictions on hiring and firing apply only to firms having more than 100 employees. Manufacturers often choose to set up many small plants instead of a few large ones in order to avoid labour market regulations. India has half of China's GNI per capita so currently has a comparative advantage in unskilled labour-intensive industries [C7]. Productivity for cutting and sewing is around 11 blouses per worker per day (see below).

Indian productivity for blouses

Number of blouses*	**32.5 million**
Productivity per employee per day (number of blouses)	11.5
Productivity per employee per year† (number of blouses)	3,500

* Based on UK imports in 2004.

† Based on 50 working weeks per year, six days per week.

During 2004, the UK imported 32.5 million viscose blouses, worth £715 million and weighing 6,500 tonnes, requiring around 58 million tonne-kilometres of transport. To produce the fabric 7,500 tonnes of viscose yarn is woven into fabric (i.e. about 15% viscose waste arises in the production). After desizing, dyeing and finishing, 7,200 tonnes of fabrics are left, to be sewn into blouses.

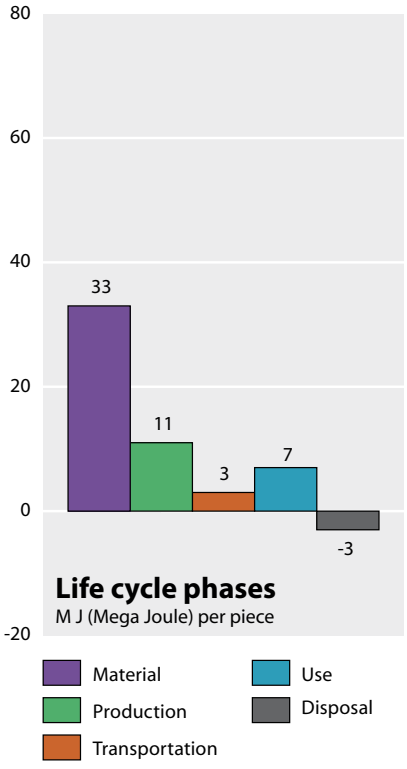
Primary energy profile

The energy profile for the Blouse is shown. It has a strikingly different shape compared to that of the T-shirt. The energy consumption of the material phase dominates (65% of the total). Approximately 50% of the energy consumed in the production of viscose is of renewable origin ("from the basic feed-stock wood") and the output from the viscose factory is filament yarn and not fibres, so there is no need for an additional yarn manufacturing stage as required for cotton. The production phase is less energy consuming (11MJ compared to 24MJ for the T-shirt). The importance of the selection of materials will be explored in the theme "New products and material selection".

The use phase of the blouse is much less energy intensive consuming only 7MJ (14% of the total) compared to 65MJ for the T-shirt. This is primarily a result of the much less extensive maintenance, for instance only washing at 40°C without tumble drying or ironing. The implications of this difference will be explored later in the theme "Changes in consumer behaviour".

Further details of the assumptions made in preparing this Life Cycle Assessment and a discussion of the consequences of the analysis are given in the technical annex.

Primary energy profile for the blouse



Carpet

Both the cotton T-shirt and the viscose blouse are made outside the UK and imported – the high labour requirement for the cutting and sewing stages of production would lead to high costs in the UK. In contrast, carpet is largely made by automated machinery, so the UK's higher labour costs are less disadvantageous and a substantial fraction of UK demand is met from UK production. While woollen carpet remains a strong UK brand, the product described here is a nylon carpet – common in commercial applications – so that the three base case products include natural, processed and synthetic fibres.

Nylon fibres with polypropylene and latex-foam backing

The carpet is tufted

Lifetime is 10 years

Face fibres are dyed with acid dyestuffs

Maintenance is assumed to be vacuum cleaning

Carpet weighs 2633 g/m^2 made from: nylon pile fibres 1100 g/m^2, primary backing 133 g/m^2, and secondary backing 1400 g/m^2

UK consumption is estimated to be 8.5 million m^2 worth £255 million

The product is a nylon (polyamide) tufted carpet, with a polypropylene primary backing and a latex secondary backing. The polyamide and polypropylene will come from the USA, but the carpet will be produced in the UK.

In 2004, approximately 22,500 tonnes of this type of carpet were imported to the UK, the equivalent of 8.5 million square meters. 190 million tonne-kilometres of transportation was required.

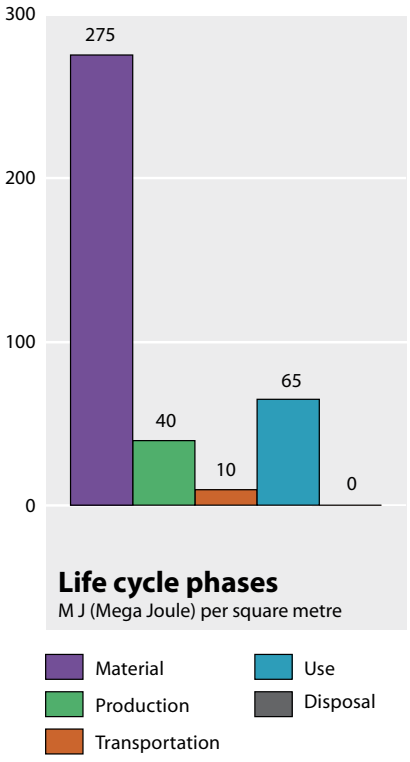
The UK has relatively high productivity levels in clothing and textiles: UK productivity in textiles, clothing and footwear manufacturing is around £35,000 per employee per year [C8]. Improved productivity stems from upgrades in technology and relocation of labour-intensive activities to lower cost countries. The standard working week in the UK is 37.5 hours, five days a week and every employee is entitled to a legal minimum of 20 days holiday per year. Shift work and longer hours are common in manufacturing. Working hours have become more flexible recently and home work has become more common so that transport delays can be overcome and work and family life can be accommodated. However, increased competition in the clothing sector from low labour cost countries has meant that the rate at which clothing and textiles jobs have been lost has increased since 1999. Employment in textiles is now higher than in clothing [C9].

Primary energy profile

The energy profile for the carpet base case is shown (per square metre). It shows similar proportions to that of the blouse. The carpet weighs approximately ten times more than either the T-shirt or the Blouse. The material production phase is very important – approximately 71% of the total energy. This is partly the result of the relatively large energy consumption in the production of the synthetic fibre polyamide – approximately 160MJ per kg – compared to about 50MJ per kg for cotton. The use phase includes vacuum cleaning only.

From the non-renewable crude oil cradle to the incineration grave the total energy consumption for the carpet amounts to approximately 390MJ per square metre or 150MJ per kg. Note that approximately 50% of the weight of the carpet is limestone and rubber i.e. not textile fibre materials. Further details on the assumptions made and a discussion of the consequences are given in the technical annex.

Primary energy profile for the carpet



Location of clothing and textiles production

Most clothing and textiles products purchased in the UK have made a journey across the globe before arriving in retailers' shops. The UK clothing industry depends on a global production system, designed to minimise costs at each stage of the supply chain. In this theme we will investigate the effect of producing goods closer to the final customer, including the possibility of using new production technologies and recycling materials. Three scenarios are compared with the base case from the previous section.

Scenario 1: Changing the location of existing operations

Decisions on manufacturing location are closely related to labour requirements: operations that must be completed by hand are generally located in countries with cheap labour; more knowledge intensive processes can be located elsewhere. Given that existing location decisions have largely been driven by cost considerations, would there be an environmental or social benefit from choosing different locations? As the carpet product is already largely made in the UK, this scenario considers the effect of shifting production of the T-shirt and the blouse into the UK.

Instead of manufacturing the cotton T-shirt in China, the scenario assumes that it is possible to transport yarn directly from the USA to the UK, where fabric can be knitted, bleached, washed, dyed and finished. The fabric will also be cut and sewn into T-shirts in the UK. For the viscose blouse, it will be assumed that the whole blouse can be manufactured in the UK including the production of viscose fibre and yarn. In addition viscose yarn can be woven into fabric in the UK and this will go through the stages of desizing, dyeing and finishing, prior to being cut and sewn into a blouse.

Scenario 2: Changed location with new production technology

Shifting the location of production is likely to lead to a cost increase, regardless of environmental benefits, as manual operations will be moved to higher labour cost countries. This disadvantage would be offset if new production technology were available to reduce the labour content of production – as has happened in the manufacture of carpets. Seamless knitting, stitch-free seams, 3D weaving and 3D sewing technologies are examples of recent innovative processes emerging in the garment industry [D1]. These are also called 'whole garment technologies' since an (almost) finished garment may be produced with one machine from yarn. For finishing textiles, inkjet printing can be a step closer to digitalising textile printings [D2].

Potentially such technologies may change the cost structure of production. They may also offer other commercial benefits: such technologies would allow production of smaller batches, including made-to-order production of individually designed and sized garments; the cost of stock-holding and the need for end-of-season price reductions would be reduced if production was fast and close to the retail outlet – as there would be no requirement for advance ordering of large batches; production waste – from cutting parts out of flat fabric sheets – would be reduced.

In this scenario production of T-shirts is shifted from China to the UK and a circular seamless knitting machine is used to knit seamless T-shirts directly from cotton yarn. The only transportation required is for shipping cotton yarn from the USA to the UK.

Scenario 3: Changed location, new technology and recycling

Unlike the USA, the UK does not produce cotton, principally because of the unfavourable climate. Thus, the UK does not have a natural supply of raw materials for the cotton T-shirts. In addition, cotton is an agriculturally intensive product requiring significant volumes of fertiliser, water and other chemicals. In the second scenario, the UK is assumed to import yarn from the USA. In order to remove the requirement for imports and to attempt to reduce the requirement for agricultural chemicals, the third scenario considers the implementation of recycling technologies in the UK. From recycled clothing, fibres can be reclaimed in order to spin yarn. This yarn made of recycled cotton clothing can be used for the process of seamless circular knitting again.

Implementation of this scenario would require commitment from government and consumers, and new technology. Government involvement would be required to ensure effective collection and redistribution of used clothing. Consumer attitudes towards recycling would need to develop. Recycling technology would need further development. For hundreds of years, the only technology used for extracting fibre from used fabrics has been the process of carding, in which the fabric is shredded between two stiff brushes. This process was the basis of the Lancashire shoddy trade but is of limited value as it drastically shortens the fibres in the tearing process. There is significant scope for innovation in extracting longer fibres, perhaps by extracting yarn rather than fibre from the used products.

This scenario assumes that 50% of the mass of used UK T-shirts can be extracted as useful length fibres for re-spinning into yarn as an input (after re-bleaching and re-dyeing) to seamless circular knitting to produce new T-shirts.

DURABLE CLOTHING: KEEPING CLOTHES FOR LONGER REDUCES ENVIRONMENTAL IMPACT

"Fashion by its very definition, isn't designed to last long. Consumers often wear garments too little, wash them too often, and at too high a temperature. All bad news for the environment. Can designers help to change this situation? Can clothes be designed that help us develop an emotional attachment to them, that have stories and origins that make us want to cherish them and to look after them well?" Becky Earley, 2006

The trend of 'fast fashion' is leading to an increase in the number of garments purchased in the UK and an increased rate of garment disposal. There are several bottlenecks currently limiting an increase in post-consumer recycling including collection, sorting and separation of the different textile components. Numerous material types and extensive use of fibre blends have become significant bottlenecks. Even if a major technological break-through was achieved in rapid automated identification and sorting of all kinds of combinations of blends, numerous waste streams would still arise. A large and constant stream of a specific material is essential for the economic feasibility of recovery.

A response to such bottlenecks in recycling is the development of 'designing for recovery' in the product development phase. Such design might include:

- Restricting the number of materials and blends used in products.
- Using new methods for assembling products to facilitate sorting and separation.
- Developing new textile fibre recycling technologies which cause less damage to the fibres (i.e. increasing the yield of recycling technologies).

However this could also imply a need for development or substitution with new materials. Blending is sometimes used to increase the strength of a yarn and thus increase the lifetime of products e.g. cotton/polyester blends compared to 100% cotton. The lifetime of the original clothing and textile products is essential for the environmental performance of the products – yet such blends are harder to recycle than single materials.

What are the major effects?

For the base case (making the products as we do now) and each scenario we have calculated a set of environmental and socioeconomic indicators for the T-shirt and the blouse. The results are shown on the two world maps – which to some extent act as 'graphic equalisers' – showing how the different measures change with the scenarios and between countries. Each measure is scaled consistently on both figures. Comparison of these measures gives us various key insights into the consequences of each scenario, and from the analysis we can make recommendations for future action.

Transport energy drives the impact of location decisions

For both products, the proportion of life-cycle energy used in transportation is small, so changing production location has only a small global environmental effect.

The use of novel technology to produce T-shirts shows additional benefits on a global scale – as yarn is converted directly to the product without the intermediate stage of flat fabric. The three measures of environmental impact are all highest in the UK, driven by use of electricity for washing and drying, but the figures in the USA are also high – around half of those in the UK. These impacts are principally due to the use of diesel in agricultural machinery and the requirement for electricity to power machines used for carding, combing and spinning cotton fibre into yarn. Energy use in producing fertilisers and insecticides in the USA, is relatively unimportant. However, later on in this report, in the theme headed 'New products and materials selection' we will explore the significance of these agricultural chemicals in generating environmental impacts associated with toxicity.

NEW BUSINESS OPPORTUNITIES WITH FLEXIBLE TECHNOLOGIES

Computerised seamless knitting machines combined with CAD (Computer Aided Design technology) offer a significant opportunity to achieve 'mass customisation' in the clothing industry, without increasing costs and optimising the material usage thus reducing waste. The combination of technologies can enable the delivery of a whole garment while allowing the product to remain digital until final manufacture. Digital communication of designs may also allow a clothing manufacturer to distribute production machines to multiple locations, such as retail stores, all over the country. Production and retail could then take place in a joint facility. This allows the customer to be involved in the design of the garment.

3D design technology allows the simulation of true-to-life garment and fabric draping using an 'Avatar' – a personalised body created by scanning techniques that form a virtual 3D garment over a virtual body using a 2D pattern input. This ensures that the lead-time in getting the prototype right is reduced and gives a customised final sample which is error-free [E1]. Novel digital pigment ink printing technologies can also be added to enhance this form of product innovation [E2].

TECHNICALLY FEASIBLE BUT NOT PROFITABLE: THE RECAM CARPET RECYCLING STORY

In the last half of the 1990s the EC Brite Euram recovery project RECAM (Recycling of Carpet Materials) achieved remarkable technological results. During the €5.5 million project a closed loop system for recycling of carpet materials was developed. The system had huge potential: the partners involved in RECAM (research institutions and producers of carpets and chemicals) estimated that it would be technologically possible to recycle more than one million tonnes of European carpet waste per year. A life cycle assessment study also looked very promising: implementation of the complete RECAM system would reduce all the examined environmental effects by more than 50% compared to current practice at the time. The system included collection of carpet waste, automated equipment for sorting (based on near-infrared technology), mechanical recycling of wool and polypropylene and mechanical and chemical recycling of polyamide.

As a spin-off from the RECAM project a $100 million commercial-scale plant was established in Augusta, USA. The plant was designed for mechanical and chemical recycling of polyamide carpet waste to recover the monomer caprolactam. It was anticipated that the facility would reduce the total amount of carpet waste land filled in the USA by more than 100,000 tonnes per year. However, in the autumn of 2001 the commercial plant in the USA closed indefinitely due to higher than expected production costs combined with unfavourable business and economic conditions. From an environmental textiles perspective the RECAM project was a huge technological success, with significant environmental benefits, but under current economic conditions the project has so far failed to be profitable and therefore sustainable [E3].

THE VALUE OF A JOB IN THE CLOTHING AND TEXTILES SUPPLY CHAIN

In China, more and more people involved in agriculture are migrating to cities in the hope of finding work in factories and gaining more economic freedom. These workers have often voluntarily enrolled in jobs with regular 12 hours shifts, living in 'in-site' factory dormitories. These work practices would be unacceptable in most Western economies but particularly for young women, whose alternative is to be married by arrangement into a subsistence life, the long hours and dormitory living can represent safety and freedom [E4].

Increasing or decreasing the number of jobs in the clothing and textiles sector therefore has a different meaning in different countries. In developed economies such as in the UK, any loss of jobs in clothing and textiles has been replaced by jobs elsewhere – currently, predominantly in the service sector. However, in China, such loss of jobs is not directly replaceable – and would lead to a return of the factory workers to their earlier, less developed, peasant lives.

INNOVATIVE TECHNOLOGIES MAY ELIMINATE LABOUR IN CUTTING AND SEWING

A recent trend in UK demand for clothing has been the shift to 'fast fashion' – with consumers expecting to see a more rapidly changing range of styles in a particular store. Seamless production technologies are one means to enable 'Just in time' production of complete garments.

Seamless or seamless appearance apparel is produced either with seamless knitting or stitch-free welding techniques. Examples of products made by these technologies and being sold at present include active wear, sportswear, swim wear, underwear and performance wear garments.

A complete garment can be produced on two types of knitting machines: seamless circular knitting machines and seamless flat V-bed knitting machines. Some companies making these machines are Santoni and Sangiacomo (Italy) and Shima Seiki (Japan). The costs of a single electronically operated flat bed knitting machine are around £55,000 per machine. Costs of a circular knitting machine are around £50,000 per machine. A hand operated industrial sewing machine costs around £550 [E5].

Stitch-free welding involves the fusing together of layers of fabric by ultrasonic heating, high frequency radiation or bonded adhesive films.

Both technologies may lead to quicker and cheaper production than traditional methods because less labour intensive cutting and sewing is required. They may also lead to reductions in fabric waste, energy use and noise. The developers of laser welding claim that it may save energy through removal of thermal taping in sealed seams, save material as no thread is used and may lead to simpler product repair. The developers of seamless knitting technology claim that it can be more reliable than conventional processes, and because of its low switch over time between products, can allow cheap production of small batches. The technology can apparently be applied to a range of yarns – including yarn from conventional fibres like cotton, wool, cashmere, mohair, silk, viscose, polyester, nylon, acrylic and more recent innovative high performance fibres such as polyamide micro fibres which can give more breathable, quick drying and durable clothes. Loose seamless garments can be made by manipulating the yarn's tension throughout the production process.

Recent claims made for seamless clothing production include:

- Between 2000 and 2005 the seamless and welded apparel market average annual growth was 112%. If the development of these technologies continue the traditional method of using thread and seaming may decrease significantly.
- The retail price of stitch-free welded garment is normally about 10% more than an equivalent made with traditional sewing but is 15% lighter.
- A small whole garment can be produced in about 20 minutes by seamless knitting which is 30 to 40% less time than for conventional cut and sew manufacture. Time is saved as seamless production has fewer stages and requires fewer quality checks.
- In 1998 seamless underwear represented only two per cent of underwear global production. By 2003 it rose to 18%. Currently the market for seamless apparel is estimated to be worth US$1 billion [E6].

Laser Sewing Machine

An example of stitch-free technology is the Laser Sewing Machine (developed between Prolas GmbH, Pfaff and TWI) which won the 2005 Techtextil Innovation Prize [E7].

UK policy should aim at reducing global impacts

For all three scenarios the global environmental impact is reduced, but in each case the environmental impact within the UK alone is increased. This is significant as UK environmental policy is generally focused on UK indicators alone, which is politically rational but environmentally illogical.

Moving production to the UK has a social cost in China and India

The base case shows that the contribution to GNI from these two products is very much larger in the UK than elsewhere, due to the higher gross margins available to retailers, and all three scenarios lead to increased GNI and improved balance of trade in the UK as it becomes more self-sufficient.

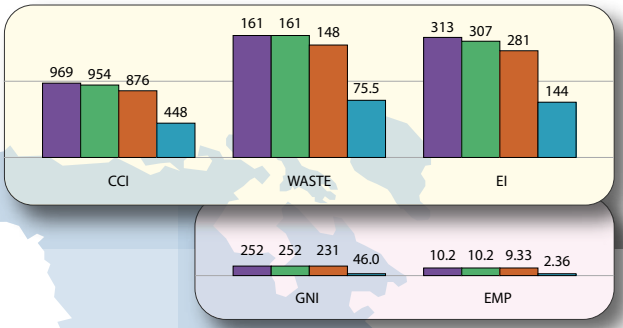
However, taking production away from China and India clearly eliminates any contribution to GNI from these products and also takes away the jobs associated with production. Economists traditionally view the significance of this effect differently in countries with full employment (UK and USA) and those with under-employment (China, India). The logic of the distinction is that in the UK, to a fair approximation, everyone who wants a job has one – so adding jobs in clothing production, as happens dramatically in the first scenario, is only possible by taking people away from other employment. It is likely that this will be harmful to the UK economy – as the free-market will already have led to the most profitable employment. In contrast, in China or India, there is an excess supply of people who would like work, but can't find it. Their alternative to employment is subsistence living. Thus the scenarios taking production from China or India to the UK has no beneficial effect on UK employment, but is harmful in China and India as it forces those employed in producing UK clothing to return to a poorer life.

Moving production from China to the UK would be expensive

Although the UK's national income and balance of trade is improved in all three scenarios, the operating surplus for the first scenario (shifting production from China to the UK with no other change) is virtually zero. The analysis has assumed that the final price to the consumer is constant, so the high cost of employing an additional 147,000 people in the UK is paid for by a loss of profitability among UK companies. It is

Scenario analysis for the T-shirt

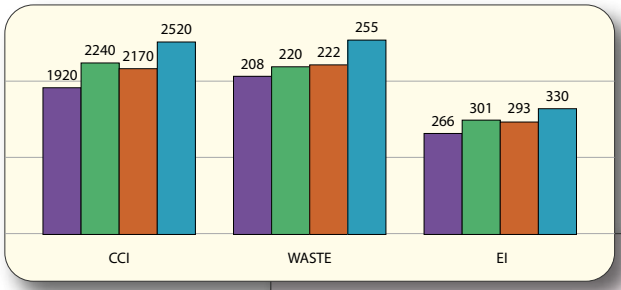
United States of America: impacts



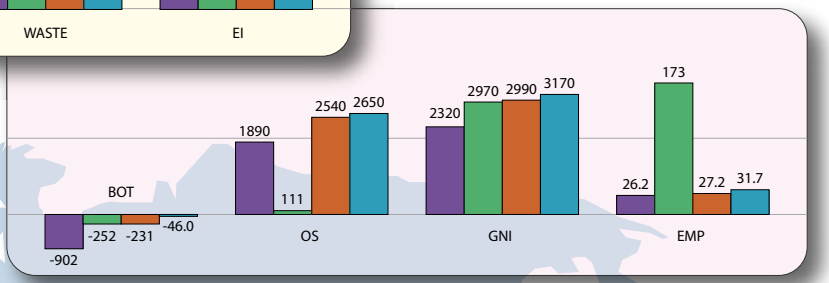
Key

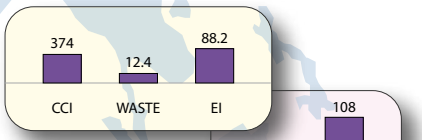
- Base case
- Changing the location of existing operations
- Changed location with new production technology
- Change location with new production technology and local recycling

CCI	Climate Change Impact [thousand tonnes CO_{2e}]
WASTE	Waste [thousand tonnes]
EI	Environmental Impact [thousand PET]
BOT	Balance of Trade [million £GBP]
OS	Operating Surplus [million £GBP]
GNI	Gross National Income [million £GBP]
EMP	Employment [thousand employees]

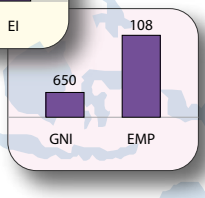


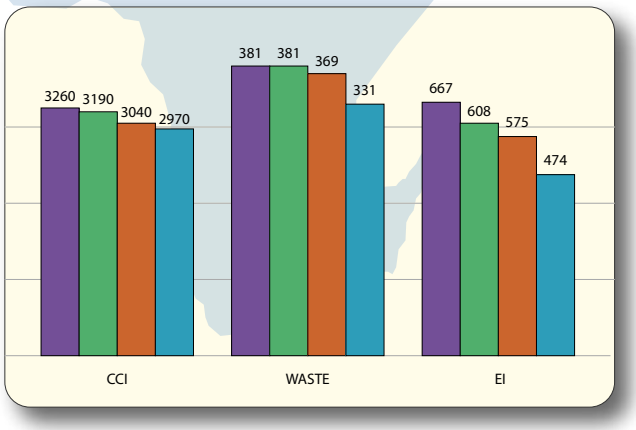
United Kingdom: impacts





China: impacts





Global: impacts

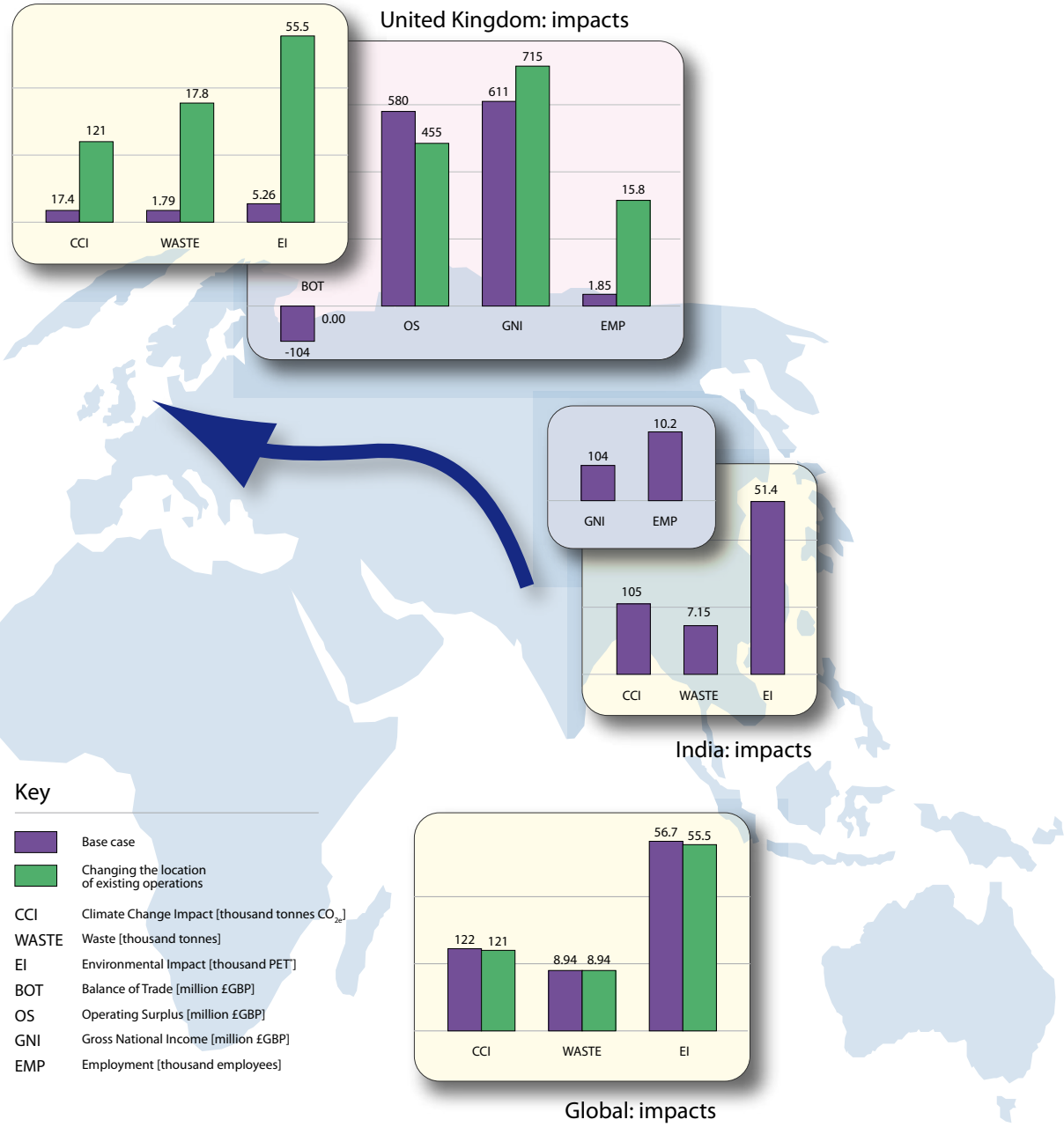
clearly unlikely that such a scenario would occur, but it demonstrates the potential value of labour saving technologies, such as those used in the second scenario. In reality, if such T-shirts were manufactured in the UK, they would be sold at much higher prices and demand would drop.

The operating surplus is a way to show this negative impact of shifting production. It measures the surplus or deficit accruing from production and takes into account compensation of employees. Since UK wages are significantly higher compared to China or India, the UK operating surplus decreases.

Labour saving technology does not benefit the environment

Without further change, the response to such higher prices would be a return of production to China and India. UK production could be protected by subsidies or import barriers, but scenario 2 shows that appropriate innovations in technology could eliminate the need for expensive labour in the UK and allow profitable UK production. Seamless knitting and other innovative production technologies are examples of such technologies currently emerging and entering regular use.

Scenario analysis for the Blouse



Seamless knitting and other such '3D clothing production' methods give a small environmental benefit through reduction in energy consumption in the production of the product (the T-shirt) and in the production of the textile raw material (cotton). However, such technologies also open up the possibility of more immediate response to consumer demands – with a machine able to make one-off clothing, it would be possible for a customer to select internet based designs from around the world and have them made to order on demand to the exact size of the purchaser. Automatic made-to-measure clothing would obviously be economically attractive and the facilitating technologies are rapidly being developed. Without further intervention by governments, it is likely that such innovations lead to some return of clothing production to the UK – driven simply by market forces.

Recycling reduces energy used in production

Recycling cotton fibres in the UK significantly reduces the environmental impacts in the USA – as the demand for virgin cotton is reduced, but leads to increased energy use in the UK where energy is required for the recycling process. The increase in waste for UK is related to the amount of solid waste generated from production of electricity compared to the waste from incineration of cotton. To produce one MJ of electricity approximately 20g of waste is generated (primarily waste from coal mining). When a T-shirt (or 250g of cotton) is incinerated only 3g of waste is produced. In the recycling scenario the amount of waste from incineration of cotton is dwarfed by the waste generated from the production of electricity to run the recycling operations. Globally, the environmental effect of such recycling is relatively small – the use phase still dominates – but most benefit is seen through reduction in the production of cotton in the USA.

As the UK's demand for cotton T-shirts is greater than for viscose blouses, the overall impacts for the T-shirt are greater. However, energy use in the life cycle of the viscose blouse is dominated by production, so if scenario three had been applied also to the viscose blouse, the relative environmental benefit from recycling would have been much greater than for cotton.

Key points from the analysis of this theme

By looking at changing the physical location of production we have learnt that:

- The dominant environmental impact seen in this theme is the washing of cotton clothes. All the scenarios investigated have had the same demand for washing, so the changes to environmental impacts have been modest.
- Recycling of both products has a significant environmental benefit. Production of viscose is more energy intensive than cotton, so recycling viscose would have a more pronounced effect than recycling cotton.
- The use of energy for transportation of these products is relatively small, so shifting location of production has little immediate environmental impact.
- Shifting production to the UK has relatively little economic benefit if full employment is assumed. Taking production away from China/India would be socially damaging as the jobs lost would not be replaced.
- Even though all clothing production in these analyses is assumed to occur outside the UK, the UK is by far the greatest economic beneficiary as the largest gross profit is achieved by the retailer. However, the net margin, or return on capital, would be similar for all businesses in the supply chain as the costs incurred by the retailer (labour and the rent of shops) also rise in proportion to increased turnover.
- Novel production technologies able to produce clothes directly from yarn without manual labour are being developed rapidly. Some UK retailers are already selling clothes made in this way. Once the reliability and costs of these machines are improved, they are likely to drive an increase in UK production of UK clothing, as they allow greater customisation of products and more rapid tracking of fashion.

Changes in consumer behaviour

In this theme we explore the positive impacts that UK consumers could have on the clothing and textiles sector – by changing either their buying patterns or their laundry practice. Two scenarios are compared with the base case from the previous section.

A key current trend in UK clothing demand is the growth in fashionable, low priced, 'disposable' clothing[F1]. H&M, Topshop and Inditex are examples of companies providing relatively low priced fashionable clothing through flexible, fast supply chains which allow clothing collections to be changed every two to three weeks. This encourages consumers to shop more often and the number of items bought annually is growing. In response to this trend, supermarkets like Asda and Tesco and clothing chains like Primark and Matalan, have developed high fashion brands at very low prices. In some cases these outlets are able to make rapid copies of famous designers' fashion items. In 2005, 19% of all clothing and footwear was bought in supermarkets[F2]: the combination of convenience and affordability is attractive.

Scenario 1: Extending the life of clothing

There is a clear environmental disadvantage to the increased flow of goods associated with 'fast fashion': the most sustainable management of clothing and textiles products would be to use them until the end of their 'natural' life – but fast fashion supposes a rapid turnover of clothing which will be discarded long before the product is degraded. The first part of this theme therefore explores ways to extend the life of garments prior to disposal: leasing, buying second-hand clothing and repairing clothing to extend the life after minor damage. All three approaches in this scenario have the same broad effect in extending product life, so we have performed our detailed analysis for second-hand clothing only.

Leasing clothes instead of buying them

Initially the idea of leasing clothing rather than purchasing it seems unattractive to many consumers. However, for some clothing and textile products leasing is already common practice. Examples of leasing include: formal and evening wear; maternity clothes; school uniforms; sports clothing; linen for restaurants or hotels; uniforms for hotels; protective clothing in industry; wedding clothes. Typically such uses are either for work or for a specific short term purpose, so the consumer does not feel an emotional attachment to the product. Leasing is an effective way to use products for more of their potential life.

Second-hand clothing

The idea of taking used clothing to a charity shop or clothing bank is well established in the UK and around 30% of clothing disposed in the UK is collected in this manner. The remaining 70% is sent to landfill (60%) or incineration (10%) (refer to the UK clothing and textiles mass balance in this report). However, very little of this clothing is re-sold in the UK – most of it is baled and sold on a commodity market abroad. The

largest UK organisations involved in the collection and processing of second-hand clothing are Recyclatex and the Salvation Army (through collaboration with Kettering Textiles).

For the scenario on second-hand clothing the viscose blouse is taken as an exemplary product. It is assumed that UK import demand for viscose blouses will drop by 20% because of increased use of second-hand clothing. Instead of 32.5 million pieces, the UK import demand will thus drop to 26 million.

Repairing clothes

In less affluent times in the UK, and less affluent countries at present, repair is a normal activity and one or two outfits can last an individual for many years.

Sorting second-hand clothes

At present, with high labour costs in the UK, repair is uneconomic and the trend of 'fast-fashion' specifically aims at a culture of rapid purchasing and disposal. Clothing supplied through leasing arrangements is, however, regularly repaired – and with a relatively limited range of designs it is possible to develop efficient repair systems. The box story on repair explores the possibility that it could grow in response to a desire to reduce the flow of new materials through the UK.

Scenario 2: Best practice in clothes cleaning

As described in the 'base case' the environmental impact of clothing and textiles products will in many cases be dominated by the 'use phase'. A garment has to be maintained, including cleaning, drying and pressing [F3], but the owner can choose how to do this. Because of the dominance of the use phase in determining the environmental impact of the product, such choices have a big impact. In this scenario, we assume that the cotton T-shirt is laundered 25 times during its life. In scenario 2a, we assume only that the wash temperature is reduced from 60°C to 40°C. In scenario 2b, we assume additionally that the T-shirt is hang-dried and not ironed.

REPAIR: QUAINT HISTORY OR A NEW BUSINESS OPPORTUNITY?

"A stitch in time saves nine" has almost lost its meaning in the UK, as the low price of clothing makes replacement cheaper than repair for many 'fast fashion' garments. Yet, as seen in the analysis of this theme, for products where energy use in the production phase is dominant, the old proverb may be just as true: a stitch in time, to prolong the life of the garment, could often use nine times less energy than replacement with new materials.[G4]

Clothing repair has traditionally been a home activity and until recently would have been a regular part of a woman's role. At present in the UK, professional repair is available through tailors or some dry cleaning shops, and high labour costs make this unattractive in many cases. What could be done to promote clothing repair in the UK?

Some labels sell their clothes with a special repair kit [G2] – often including buttons, or other fittings and appropriate thread for hidden stitching. Garments could be designed to facilitate repair – for instance with cuffs and collars on men's shirts being designed for easy removal. Manufacturers could supply spare parts – as is normal in the car industry – to facilitate repair and – as with car makers – could achieve higher profit margins on the spares, while reducing demand for virgin material.

Consumers could buy fewer higher quality garments – with the expectation of repairing them rather than disposing and replacing them when minor damage occurs. Discarded clothing could be upgraded by some form of remanufacturing: for instance replacing certain panels within a dress might allow a sufficient 'fashion upgrade' to give new value to otherwise outdated styles. This approach has been used in the Smart Car – with simple replacement of body panels to allow a cheap change of style.[G1]

Eco-carpets give an example of textiles remanufacturing, where carpets are taken back to the original manufacturer to be cleaned, texturised, reprinted and cut into carpet tiles for reuse in a new location. "The UK installed carpet base is around 85 million m^2, and is replaced at 12 million m2 per year. A new conventional carpet consumes five barrels of oil per 100 m^2 while remanufactured tile carpet consumes 1.2 barrels, including transport".[G3]

What are the major effects?

As before we calculated environmental and socioeconomic indicators for the scenarios and present the results on two world maps. For this theme, the scenarios involve change only in the behaviour of UK consumers. However, the consequences of their behaviour are felt elsewhere if the total demand for products is reduced.

The number of wash cycles drives environmental impacts

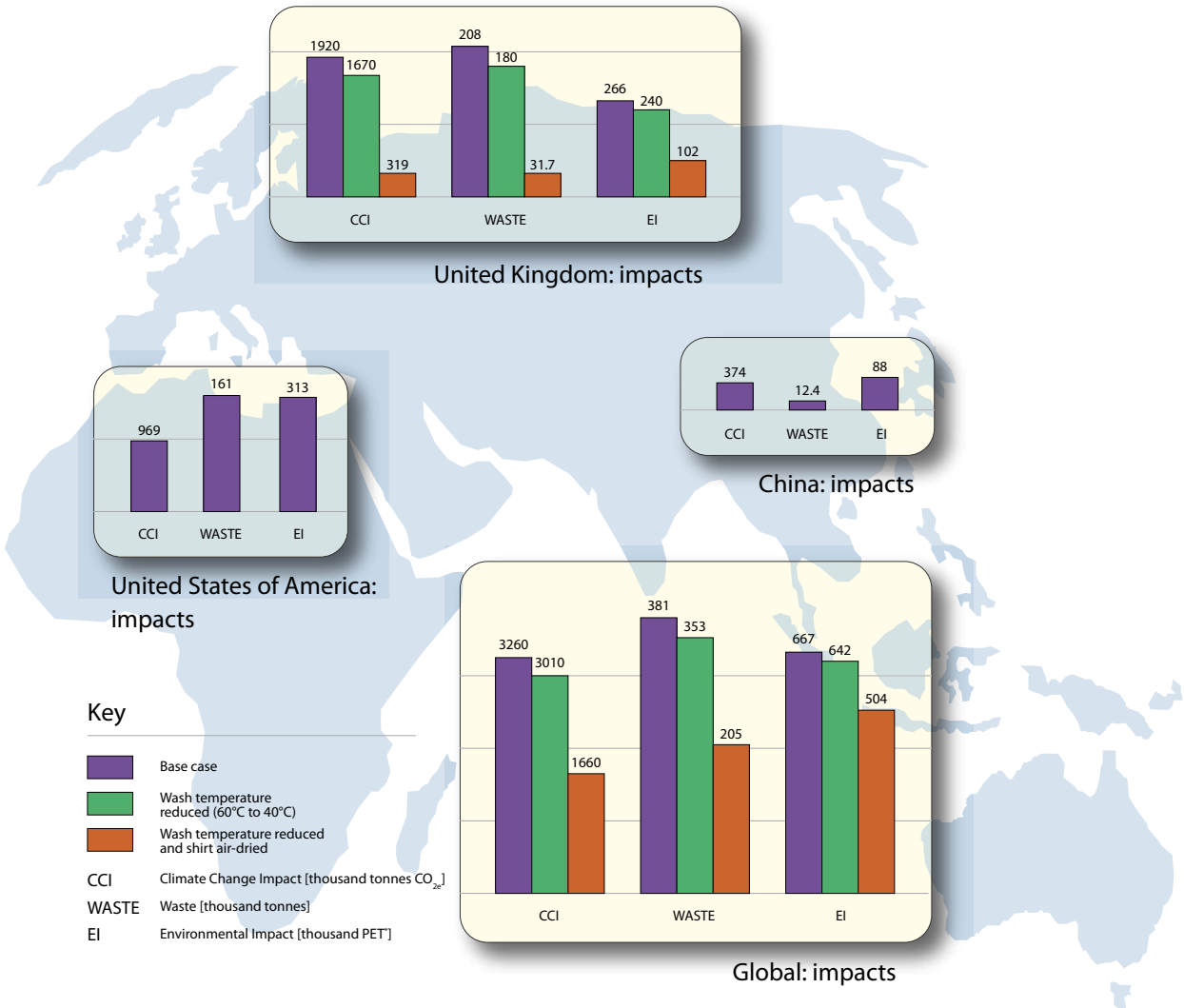
Better practice in washing the T-shirt has a significant impact on the life-cycle of the product. Washing at a lower temperature reduces all environmental impacts in the UK and has a modest reduction (of around 10%) in global impact. However, elimination of tumble drying (which uses around 60% of the use phase energy) and ironing, in combination with the lower wash temperature, leads to around 50% reduction in global climate change impact of the product.

Economically, such changes make no impact at the national level, and at current energy prices are not dramatic: replacing a washing machine bought in 1995 by an energy saving version will save two thirds of the energy used, worth around £10 per year; avoiding use of a dryer would save about £25 annually for an average household [F4].

Keeping clothes longer reduces production impacts

Extending the life of clothing so that demand for new products is reduced by 20% leads to a reduction of about 20% in all measures in the producing country (India in this case) and no significant change in the UK. For the blouse, where the impact of the production phase dominates the use phase, this leads to a reduction of about 15% in the global impact (for all three categories) of the product – which is clearly significant. Extended use of products with high impact in the production phase therefore gives

Best practice in cleaning cotton T-shirts



HARM FROM PHOSPHATES IN DETERGENTS

The phosphate content of washing powders can be up to 30%. Washing liquids normally contain fewer phosphates than washing powders, with tablets having the highest concentration. Discharging phosphates to the waste water stream promotes the growth of green algae which, in excess, can limit the survival of various water-based organisms. The World Wildlife Foundation recommends washing liquids containing less than 5% phosphates, the best option being phosphate free brands [G5]. Exemplary eco-labelled detergents do not contain any phosphates and are said to be 100% biodegradable. At the Greenpeace website (www.greenpeace.org) consumers are able to check which washing powders and liquids are better for the environment.

LEASING CLOTHING: AN OPPORTUNITY TO INCREASE THE USE OF EACH GARMENT

Most of our personal clothing is under-used and discarded before it is beyond repair. If we leased clothing instead of buying it we could have access to a wider range of styles and sizes, store less clothing at home and each garment would be used more intensively – so leased clothing could be cheaper and our total demand for virgin material would be reduced. Is clothing leasing a sensible proposal?

Our requirements for clothing are physical and aesthetic. Clothes and textiles are required as protection from a specific environment or temperature and for hygienic needs and cleanliness. They are also worn to enhance personality, to please others, to conform to a gender, group, or to show hierarchy and to illustrate status in ceremonies. Several studies show that in Western European countries the reasons people buy clothes (in order of priority) are [G2]:

- They want to follow a change in fashion.
- They are attracted by a low price.
- They want to dress for a special occasion.
- The are attracted by a brand or 'label'.
- They have a regular shopping habit.
- They need to replace old worn-out garments.

The potential attractions of leasing clothes are:

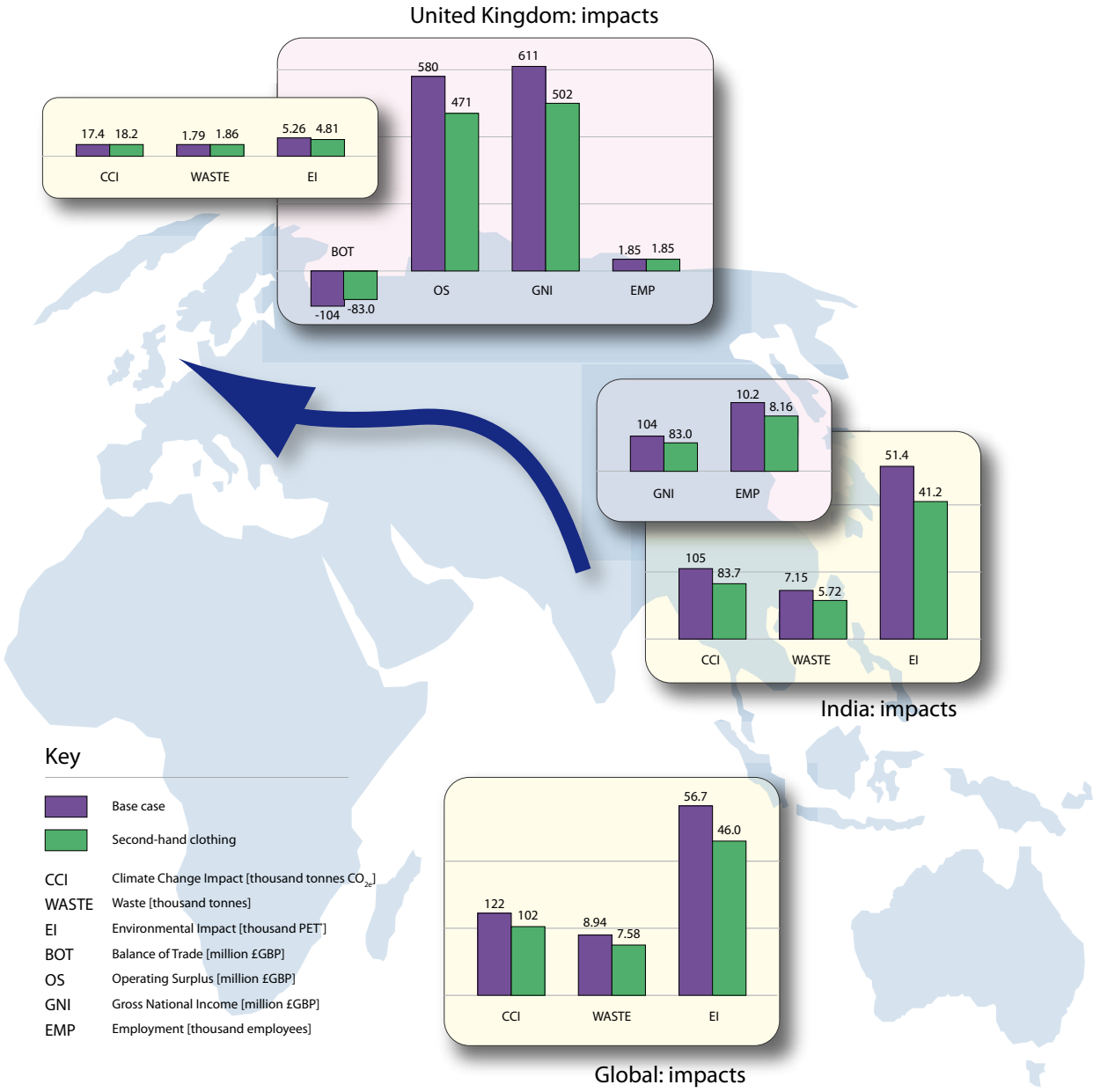
- The cost per outing of a garment can be reduced .
- Simpler maintenance – clothes are returned after use.
- Clothes can be leased for a variety of purposes and functions or for a special environment.
- Leasing gives cheaper access to special clothes for a short time – for ceremonies, or to follow rapid changes in fashion.
- It helps to address social or cultural attitudes towards the need for variety – for instance for women's work clothing.

In the UK at present, leasing is not common for personal clothing, but is used for uniforms and working clothes, catering linens for restaurants and hotels, costumes and wedding outfits and maternity wear. However, consumer lifestyles and attitudes to clothes are changing. The rise of fast fashion and very cheap ('disposable') clothing has reduced the significance of personal ownership. The possibility of leasing allows fast change-over of garments, worn only a few times by each person, without the need for fast disposal. A key challenge for leasing is to develop garments that remain popular for sufficient time, despite the rapid move of fashion.

A further attraction of leasing is that clothes maintenance and repair could be carried out in higher volumes at specialised facilities. Already, the technology and know-how in professional laundries requires less detergent, chemicals, water and energy per kilogram of laundry than for home washing. New eco-efficient cleaning technologies could be more easily applied at a larger site.

In order to understand the potential of leasing clothing, we conducted an eight week study on leasing. We found that it would be possible for consumers and retailers to make a profit from the leasing of certain kinds of garments rather than buying or selling them although this may be confined to markets where the lease period is short and the number or wears per month is low [G6].

Extending the life of the viscose blouse



a clear environmental benefit. However, existing flow of second-hand clothing in the UK does not have this impact – because the clothes are mainly not re-sold in the UK, so demand for new production is not reduced. The benefits described here depend on an absolute reduction in production.

The disadvantage of such a cut in demand is a loss of employment in India. However, extending the life of products by recycling, leasing or repair also creates new jobs, both in the UK and abroad. For the second-hand clothing market to function, garments must be sorted and distributed.

Waste sent to UK landfill is mainly from electricity generation

If clothes are used for longer, the rate of flow of new clothes into the UK is reduced, and hence the rate of disposal of clothing will also be reduced. However, the total waste sent to landfill in the UK has increased slightly. This is because the analysis attempts to include all key elements of the product impact, and includes the material used to generate electricity for the use phase. This leads to some surprising results:.

- To provide the electricity required for the use phase of a 250g cotton T-shirt requires 1.7kg of fossil fuel (i.e. for the base case).
- The fuel is incinerated leading to a small residue of

ash – around 10g and the T-shirt is incinerated at end of life to leave around 3g of ash (and generate some useful heat – which is accounted for in the analysis).

- Consumption of the 1.7kg of fossil fuel creates around 0.45kg of waste (primarily mining waste from coal mining) which is sent to landfill.
- Burning 1.7kg of fossil fuel leads to emissions to air of approximately 4kg of CO_2 equivalent.

Thus the total mass of material sent to landfill during the life cycle of the T-shirt is dominated by the wastes from mining fossil fuel to generate electricity for the use phase. As this phase is unaffected by extending the life of the product, so UK waste is increased by slowing the rate of new clothing purchases.

Key points from the analysis of this theme

From exploration of the impacts of consumer behaviour we have learnt that:

- The effect of reducing the energy used in washing, drying and ironing cotton T-shirts dwarfs the possible effects of changing production methods or structure. Omitting tumble drying is by far the most important step. For cotton garments, where use phase energy is dominant, a change in consumer behaviour is required.
- Purchasing a 250g cotton T-shirt implies purchasing 1,700g of fossil fuel, depositing 450g of waste to landfill and emitting 4kg of CO_2 into the atmosphere. These figures are largely driven by the energy required to launder and dry the T-shirt during its life cycle.
- The value of recycling depends on the ratio of energy consumed in the use phase to the production phase of the product. For viscose and synthetic materials, such as nylon and polyester, recycling has a significant benefit. This is seen in reduced emissions at the location of production (India) but comes with the cost of reduced economic activity.
- In some cases, the economic activity of production could be substituted by an equally valuable activity of repair, renewal and recycling with a net environmental benefit and no economic loss.

Behind the analysis of this theme, lies the question of whether UK consumer attitudes are likely to change. Is it possible that UK consumers will switch from 'fast' to 'durable' fashion?:

- The price of a second-hand viscose blouse which can be as low as £2, compares favourably to a new blouse costing cost £22 (base case).
- Second-hand clothing can be sold without hygiene problems or damage, but crucially it will be last year's fashion – so is less attractive to fashion following consumers.
- UK spending on garments was about £625 per capita in 2005, but spending on clothing cleaning, repair and hire was less than two per cent of this. Consumers are thus not economically motivated to reduce cleaning costs by saving energy, but conscientious consumers could save money by spending more on repair and second-hand purchases and less on new products.
- Moving to eco-friendly washing liquids is neither more expensive nor less effective than regular washing liquids.
- Most people in the UK believe that recycling is good for the environment and will generally sort out glass for recycling carefully, without recognising that it takes ten times more energy to make a tonne of textiles than a tonne of glass.

New products and material selection

Chemicals are widely used in the clothing and textiles sector – as pesticides and fertilisers in cotton farming and for dyeing yarns and fabrics. Intense use of chemicals may be harmful to the natural environment, to employees working in the industry and, in extreme cases, to babies and children wearing finished garments. In this theme, we consider various changes that might lessen the demand of the sector for chemicals with undesirable side effects.

Scenarios

The first scenario considers the substitution of existing fibre sources with new or traditional alternatives. The second scenario considers direct means to reduce chemical demand with existing materials and processes – through organic farming of cotton and substitution with less toxic chemicals. The third scenario considers the implications of various potential and innovative 'smart functions' such as novel coatings that extend the life of a textile product, or reduce the number of times an item of clothing must be washed by increasing its resistance to stains or odours.

Scenario 1: Alternative fibres

All three of the products considered in this analysis could be made with similar functions but from different fibres. Cotton is the most common natural fibre used for clothing, but natural fibres such as wool, linen and silk are also common and other possibilities include hemp, ramie, flax, jute, sisal and coir. At present, production of these fibres is falling while demand for cotton is steadily increasing – but cotton agriculture is chemically intensive and in the future less demanding alternatives may become more common. There is also growing interest in 'bio-fibres' renewable, short life cycle (annual) fibres obtained in principle by agriculture. Examples of bio-fibres include bamboo, soy, algae, maize, agricultural waste and nettle.

World production of man-made fibres, like polyester, polyamide, polypropylene, polyacryl, acetate, cupro and viscose has increased in 2004. A smaller group of synthetic fibres like elastane, aramid and carbon fibres accounts for only a little more than one per cent of total man-made fibre production in 2004 [H1]. The man-made fibre industry comprises the cellulosic and non-cellulosic fibres and yarns. Cellulosics include viscose, acetate and cupro. These fibres are regenerated from chemically treated cellulose, which is originally derived from pulp in nature. The non-cellulosic mostly called 'synthetic' fibres and yarns include acrylic, nylon and polyester. These are derived from polymers produced from simple chemicals primarily from petrochemicals [H2]. The production of man-made and synthetic fibres are both energy-intensive processes. As shown in the base case analysis of the viscose blouse and polyamide carpet, energy use in production is dominant.

To reduce the environmental impacts of producing these materials, attempts are being made to create alternative fibres from renewable materials. For example, novel man-made fibres of natural origin like Tencel® (lyocell) made from wood and Ingeo® (poly lactic acid) obtained from corn, have been developed [H3].

The carpet product used for scenario analysis in this report has polyamide face fibres. In order to examine the impact of substituting a natural fibre for a man-made fibre, in the first scenario of this theme, the carpet face fibres are replaced by wool. Wool represents about three per cent of total world fibre production. The UK sheep population in 2004 consisted of 25 million sheep and UK raw wool represented about 2.3% of world production in the same year. Most British wool is exported [H4].

THE ARAL SEA: AN ENVIRONMENTAL DISASTER CAUSED BY COTTON GROWING

Environmental damage created by mismanaging natural resources and failing to account for the environmental impact of decisions is exemplified by the drying up of the Aral Sea, one of the largest man-made ecological disasters. Once the fourth largest lake on earth sustaining a vibrant economy, with many people relying on fishing and agriculture for their livelihoods, the Aral Sea has shrunk by three-quarters over the past few decades.

The disruption began in the 1940s when Soviet policies, aimed at cotton self-sufficiency, led to a massive diversion of water for irrigation from Central Asia's two big rivers: Uzbekistan's Amu Darya River in the south and Kazakhstan's smaller Syr Darya in the north. The rivers were later converted into canals to irrigate cotton plants across the region [J1].

Since this heavy irrigation began in 1961, the inland sea, which received most of its water from these rivers, has shrunk to half of its former surface area. In the five countries which share the Aral Sea Basin more than 20 million people depend directly or indirectly on irrigated agriculture [J2].

The Aral Sea has split into two; dust storms have increased, contaminating agricultural land with salt; water that makes its way back to the sea is gradually more saline and polluted by pesticides and fertiliser. This has resulted in thousands of job losses and severe degradation of the surrounding environment, creating poverty and causing illnesses such as respiratory diseases and cancer amongst local people.

Recent surveys predict a complete drought in as little as 15 years. In 2003, the government of Kazakhstan and the World Bank began a massive restoration project for the Aral Sea [J3], addressing economical, social, environmental and health effects. The northern Small Aral Sea will be allowed to refill from the inflow of the Syrdar'ya, and though it is never expected to regain its former size, planners think that it will refill enough to support robust fishing again. It should also help to stabilise the continental climate – increasing rainfall, smoothing out winter-summer temperature extremes, and suppressing dust storms. Rich delta ecosystems were largely lost. A new dam will allow the accumulation of over 29 cubic kilometres of water into the Small Sea and will help to restore delta and river line wetland ecosystems.

Aral Sea (July-September 1989)

Aral Sea (12 August 2003)

Source: NASA's Earth Observatory

Scenario 2: Green manufacturing

According to the Organic Trade Association, "organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and management practices that restore, maintain and enhance ecological harmony" [H5]. Organic cotton is defined as cotton that has been grown without any use of synthetic fertilisers, synthetic pesticides and defoliated by natural means [H6]. Interest in organic cotton is growing with increasing awareness of problems with higher soil toxicity and the harmful effects on workers and consumers from conventional pesticides and fertilisers [H7]. However the production of organic cotton is still less than one per cent of the total cotton production.

In the conventional cotton industry pesticides are sprayed over the cotton crops, causing serious health problems to cotton workers [H8] and soil degradation. Synthetic insecticides for cotton are associated with large-scale poisoning and deaths in producing countries. Organic cotton production abolishes synthetic pesticides, but makes use of natural pest killers like beneficial insects and 'trap crops', to keep away harmful insects [H9].

Water consumption can also be a major environmental issue in connection with cotton production. The actual water consumption is in the range of 7,000 to 29,000 litres per kg of cotton fibres. This is at least 20 times higher than the amount of water used in the subsequent production of textile products (e.g. dyeing and finishing) [H10]. Uncontrolled diversion of water for irrigation can have dramatic consequences as seen in the Aral Sea disaster (see 'The Aral Sea: an environmental disaster caused by cotton growing' in this section for more background information).

At present, organic cotton is more expensive than conventional cotton; however over time this difference may reduce. The Research Institute of Organic Agriculture claims to have found significant advantages of organic over conventional cotton in cotton farming in central India. The number of pest management days needed per year is reduced by around 40%. The costs of fertilisers and pest management were significantly reduced [H11]. A study of African cotton farming claims that organic cotton crop growing improves yields per acre, enhances soil fertility and enhances food security [H12].

In 2004, a report from Greenpeace raised awareness of the presence of hazardous toxic chemicals in Disney clothes [H13].

Many of the manufacturing processes used for fibres and yarn, for instance in pre-treatment, dyeing and printing, are chemically intensive. However these substances can be avoided. According to the Danish Environmental Protection Agency (EPA) [H14] for all uses and in all circumstances a suitable less toxic alternative can be found.

The second scenario therefore considers manufacture of the T-shirt from organic cotton, grown without pesticides and with less toxic chemicals used in processing. In the scenario analysis, organic cotton will be grown in the USA and organic cotton fabric and T-shirt will again be produced in China.

Scenario 3: Smart functions

Research in novel nanotechnologies and in bio-sciences is driving innovation in so-called 'smart functions' for clothing and textiles. These technologies are still largely at the development stage, but promise a range of methods to change the behaviour of clothing and textiles in use – usually through application of a coating to existing fibres, yarns or products. Possible functions include variable insulation, improved resistance to water, or sensitivity to sunlight.

In the third scenario, we consider two candidate futuristic developments of the carpet and T-shirt products with novel smart functions. The T-shirt will have a stain resistant coating derived from nanotechnology, which is assumed to halve the number of washes required during the product's life. For the carpet, a protective nanotechnology treatment will ensure that the carpet's lifetime will be extended from 10 to 20 years.

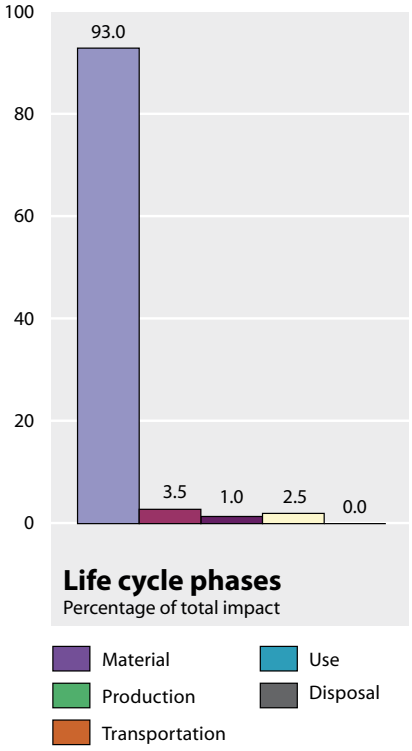
Analysis

As with the previous two themes, we have predicted environmental, economic and social consequences of the scenarios given above for T-shirt and carpet. In addition, for the scenario comparing conventional and organic cotton, a detailed life cycle study of toxicity has been completed.

The toxicity profile for the T-shirt base case is shown (per T-shirt), illustrating the toxicity of the emitted chemicals in the four major phases of the life cycle. The toxicity data used for the study includes the major chemicals in the production of cotton, dyestuffs and chemical auxiliaries used in the production of the T-shirt as well as washing powder in the use phase. The data used for cotton production represents a 'worst case' toxicity scenario and includes consumption, emission and toxicity data for the five major chemical groups used in cotton production – insecticides, herbicides, fungicides, growth regulators and defoliants (more details on basic references, assumptions and calculations are provided in the technical annex). For the production and use phases biological treatment of waste water is assumed.

The figure shows that the material phase (production of the raw cotton fibre) completely dominates the toxicity evaluation. Thus the toxicity impact from the five major chemical groups listed above is far more important than that from other operations in the production of raw cotton such as the use of machinery for cultivation and harvesting.

Toxicity profile for the T-shirt base case



NOVEL MAN-MADE TEXTILE MATERIALS

Market research from Globescan Eurisko claims that 85% of Italian consumers, closely followed by Germans, Canadians, Great Britons and finally Americans would be happy to pay an extra 10% for a product that does not harm people and the environment [J4]. Two approaches to creating materials claimed to be more environmentally benign, are described here:

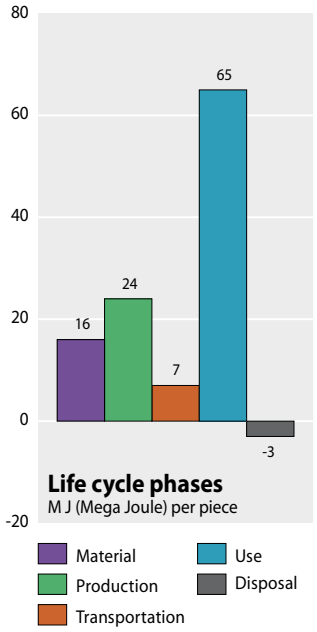
Ingeo – meaning ingredients from the earth – is a fibre made from corn by Nature Works LLC [J4]. To obtain this fibre, corn is first separated into starch then to dextrose corn sugar, then to lactic acid which is converted to a PLA (poly lactic acid) polymer, finally the fibre is extruded from this polymer [J5]. According to the manufacturers, Ingeo combines the performance of a synthetic fibre with the advantages of a natural material and it is compostable in commercial composting facilities [J6]. Its production uses 20% to 50% less fossil fuel and releases a lower amount of greenhouse gasses. Because the refractive index of the fibre is low, fabrics can be made with deep colours without requiring large amounts of dye. Sorona bio-PDO is also made from corn and has similar properties to Ingeo.

Where Ingeo® (PLA) and Sorona® (PDO) are corn-based and fast growing, Viscose®, Modal® and TENCEL® (lyocell) made by Lenzing are wood-based, obtained from sustainably managed forests. These fibres are high purity cellulose fibres made from wood pulp. Compared with cotton, wood has the advantages of low water consumption, reduced pesticide use and produces up to ten times the amount of cellulose per hectare [J7]. According to the manufacturers the TENCEL® (lyocell) process was designed with the environment in mind and is a new green-fibre for home textiles, apparel and non-wovens. Being of natural origin, these fibres are 100% biodegradable and made by a clean manufacturing process. TENCEL® (lyocell) is different in that a direct solvent is used for the cellulose in a closed-loop process, where 99.6% of the solvent is recycled. This production route results in a distinctive fibre with a nano-fibril structure and natural smart functions.

This toxicity profile and the energy profile for the T-shirt presented in the 'base-case' chapter (shown again here for comparison) are strikingly different. In the energy profile, the use phase dominates (approximately 60% of the total) but in the toxicity profile, the use phase is responsible for less than five per cent of the life cycle impact of the T-shirt.

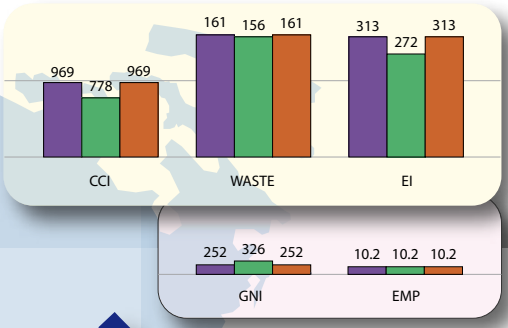
The base case analysis for the carpet shows that the major environmental impacts of carpet production occur in the USA due to the production of polyamide yarn used for the face fibres. In the UK the imported yarns are manufactured in carpets, which in turn leads to the high UK waste figure, but this is a relatively low energy low impact process.

Primary energy profile T-shirt base case



T-shirt: Green manufacturing and smart function

United States of America: impacts



Key

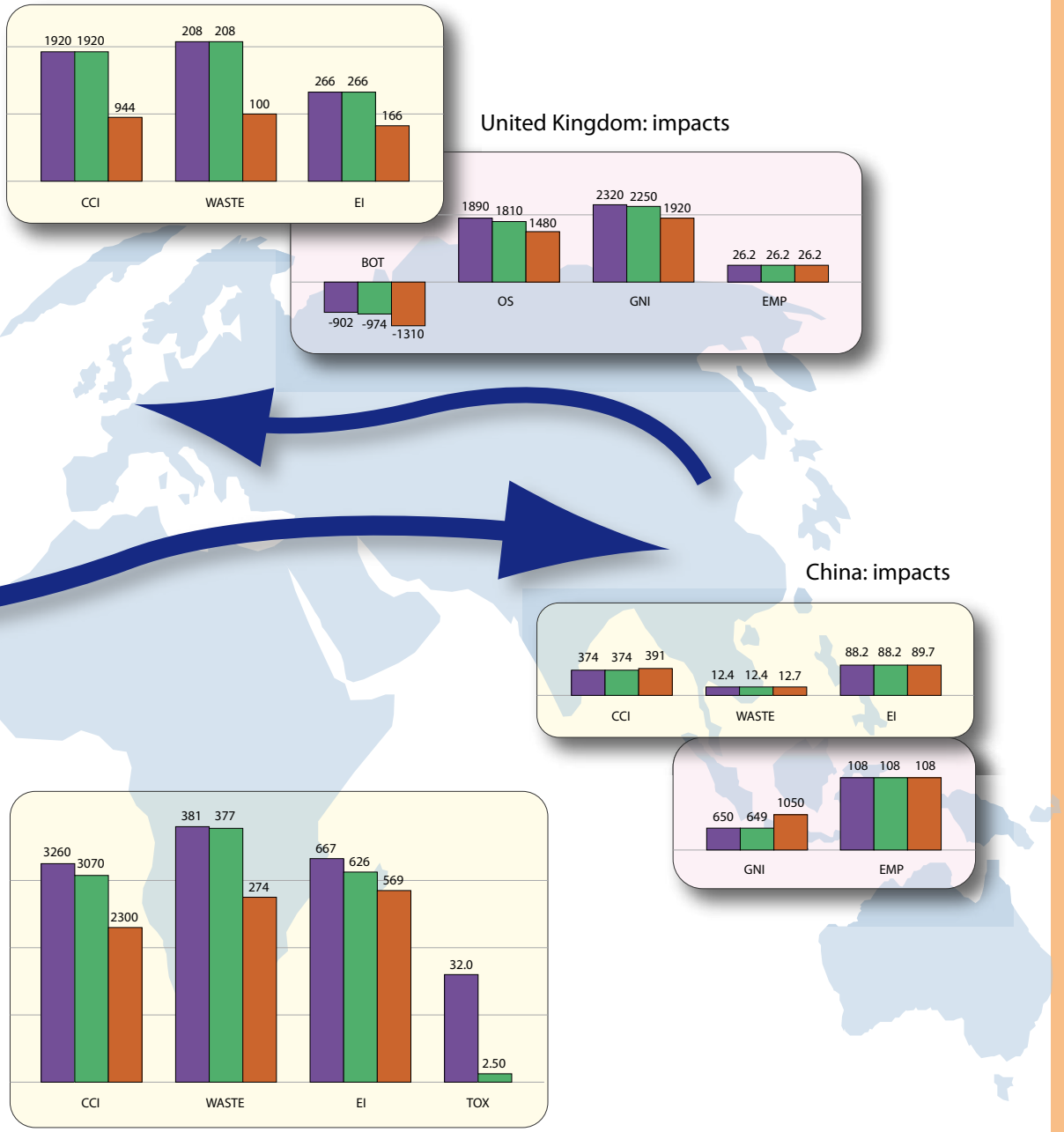
	Base case
	Organic cotton
	Nanotechnology
CCI	Climate Change Impact [thousand tonnes CO_{2e}]
WASTE	Waste [thousand tonnes]
EI	Environmental Impact [thousand PET]
TOX	Toxicity [million PET]
BOT	Balance of Trade [million £GBP]
OS	Operating Surplus [million £GBP]
GNI	Gross National Income [million £GBP]
EMP	Employment [thousand employees]

IS HEMP A VIABLE OR VALUABLE ALTERNATIVE TO COTTON?

Because of the harmful environmental impacts and uncertainties of cotton crop growing, manufacturers are finding alternative fibre sources. The T-shirt of our analysis can be made out of hemp instead of cotton. Hemp can be grown in the UK[J8].

Although hemp has been used for the production of textiles for many years, until the 20th century it was mainly used for rope, parachutes and denim. Increased need for alternative fibres in the 1980s and 1990s resulted in a renewed interest in industrial hemp. Although fibres from hemp are naturally rough, new processes have been developed to create soft but strong fabric. Hemp is four times stronger than cotton, twice as resistant to abrasion, and more resistant to mildew, soiling, shrinkage and fading in the sun. In addition, hemp plants need little irrigation and significantly less pesticide or other chemicals.

According to Crailar fibre technologies, unit production costs for hemp would be US$0.42 per pound, versus US$0.62 per pound of cotton and US$1.50 per pound of organic cotton. This cost advantage is mainly caused by a reduction in the need for pesticides, chemicals and irrigation[J9]. However, others in the cotton industry point out that hemp fibre can



Global: impacts

not as yet be spun on conventional machines, which would inhibit its adoption. A study conducted at the University of Melbourne states that hemp production for textiles, oilseed and paper as an alternative to the cotton equivalents reduces the ecological footprint of the fibre by up to 50% [J10]. Hemp is becoming a popular fibre even for catwalk designers: Woody Harrelson has worn a hemp suit created by designer Georgio Armani at the Oscars [J11].

What are the major effects?

As before, we draw several key themes from the analysis.

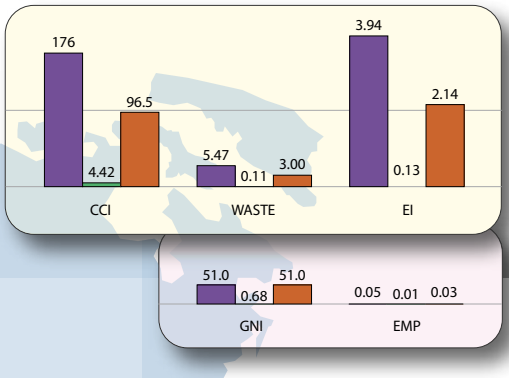
Switching from man-made to natural fibres has mixed effects

The base case environmental impact of the carpet is dominated by the production of polyamide in the USA. Substituting this with wool from UK sheep leads to a significant (65%) drop in the combined environmental indicator, with a small (five per cent) increase in climate change impact (mainly due to sheep releasing methane after digestion!) and an increase in waste (when extracting useful fibre from fleece). The global benefit in environmental impact comes after a marked redistribution in the location of the impact – from the USA to the UK, so measures of the UK's domestic impact would worsen in order to achieve a global improvement. Sourcing all raw materials except polypropylene within the UK makes the woollen carpet a localised product, showing economic benefit on all UK measures, including new jobs. However, the measures used are macro-economic, and while at a country level the operating surplus has grown, at a firm level the costs have gone up significantly, so in fact the businesses in the supply chain for the carpet would be loss making unless the price of the woollen carpet was increased, by around 50% to 100%. There is also some doubt about whether the woollen carpet would last as long as the polyamide carpet. If they had a shorter life span, the material flow to provide equivalent carpeting service in the UK would have to increase.

The comparison of carpet made with natural as opposed to man-made fibre is therefore rather complex: if the woollen carpet lasts as long as the polyamide carpet, the change leads to a small increase in climate change impact, but a large reduction in other environmental measures. Production of woollen carpet in the UK has economic benefits to the country, but would lead to higher prices for the consumer.

Carpet: Alternative fibres and smart functions

United States of America: impacts



Key

	Base case
	Alternative fibres
	Nanotechnology
CCI	Climate Change Impact [thousand tonnes CO_{2e}]
WASTE	Waste [thousand tonnes]
EI	Environmental Impact [thousand PET]
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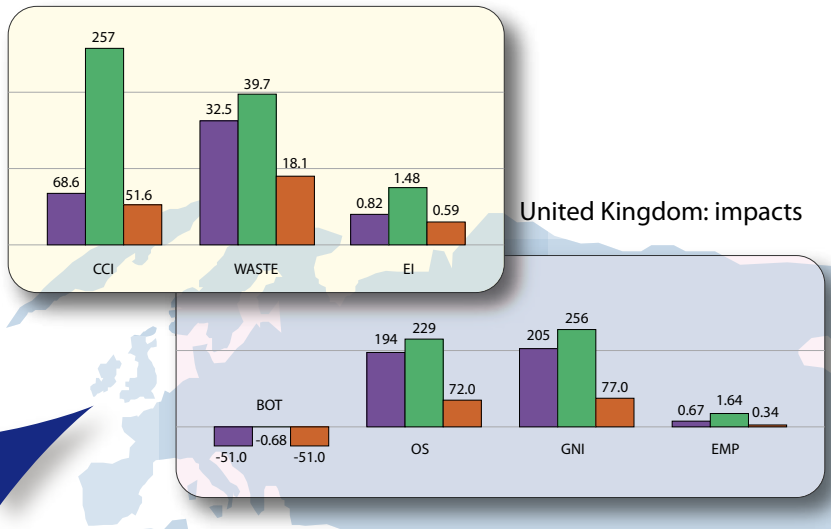
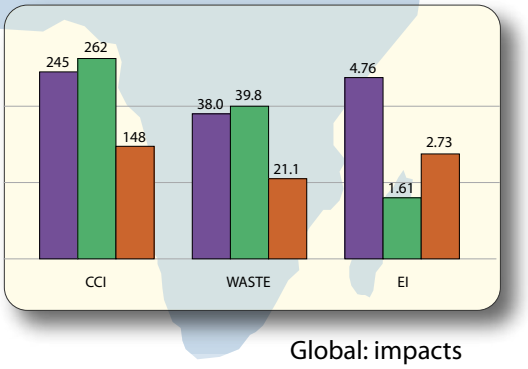
EMP	Employment [thousand employees]



United Kingdom: impacts



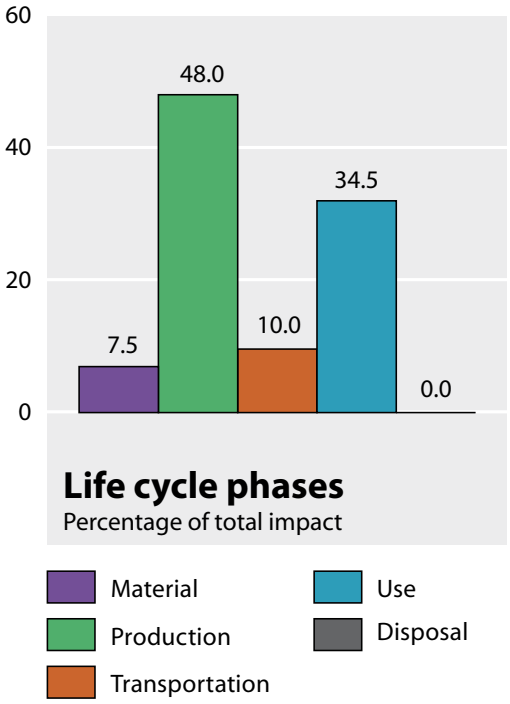
Global: impacts

Organic cotton would reduce toxicity but increase prices

The toxic impact of the cotton T-shirt through its life-cycle is dominated by chemicals used in conventional cotton agriculture, so a switch to organic cotton with less toxic dyes causes a dramatic fall (of over 90%) in the toxic impact of the product.

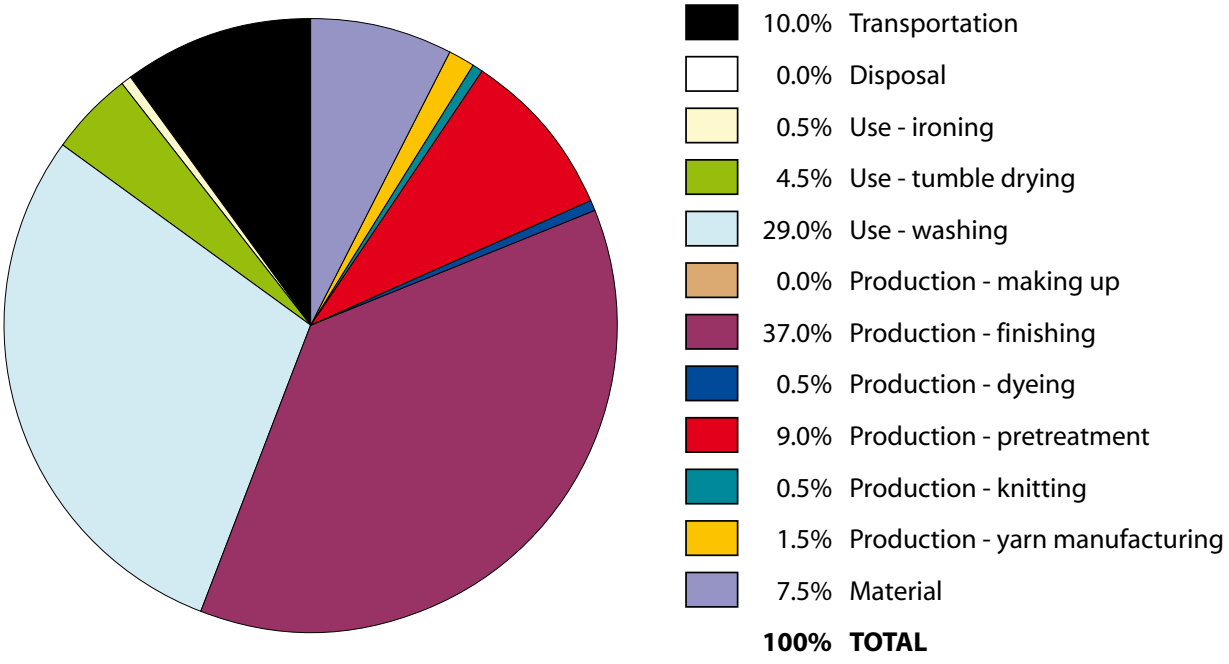
The toxicity profile for the T-shirt made with organic cotton shows total toxicity reduced to about 10% of the base case. For the organic cotton T-shirt the toxicity impact of the material phase no longer dominates as the production and use phases are now more important. To examine the causes of this, the production and use phases for the organic cotton scenario have been broken down into the major sub-processes. The production process of finishing (softening) and washing in use (at 60°C) dominate. The toxicity of clothes washing is not because the washing powder is particularly toxic or has low biodegradability but primarily because a relatively large amount of detergent is discharged to biological waste water treatment – approximately 125g in the life cycle of the T-shirt compared to only 1g of the finishing chemical. The finishing chemical used in the analysis is benzalkonium chloride a so-called quaternary ammonium compound. This chemical is widely use in the textile industry as a softening agent because of excellent softening properties but is also very eco-toxic. The figure also shows that the dyeing process is not particularly important.

Toxicity profile for the T-shirt made with organic cotton



Organic cotton is sold for 50% more in the USA than conventional cotton (in other countries the fibres usually cost less than 20% more) so the USA sees a corresponding increase in national income (hence the Balance of Trade in the UK declines). The analysis assumes constant profit margins throughout the supply chains, so all other economic measures in China

Detailed toxicity profile for the organic cotton T-shirt



Source: ICAC 2001

and the UK improve assuming that UK consumers are willing to pay a higher price for organic cotton T-shirts.

The switch to organic cotton growing in the USA would cause a switch in employment – but little overall change. However, reduced exposure to the toxic effects of agro-chemicals would generally improve conditions for employees in the sector.

Extending carpet life improves all environmental measures

The most striking feature of the carpet analysis is that the invention of an application that would double the life span of a carpet (increasing it from 10 to 20 years) would reduce all global environmental measures to about 55% of the base case values. The production phase of the life cycle of the carpet dominates the use phase. Thus as the rate of new carpet production is halved, so the impacts are nearly halved even though we have assumed that the introduction of nanotechnology in the production of polyamide fibre will increase consumption and emissions by 10% for this process.

It is assumed that new nanotechnology applications are applied by the polyamide yarn manufacturer in the USA, so the price of the yarn increases (we assume by 30 to 40%), however costs for nano-finishes go up by the same level. Polyamide yarn production is a relatively big part of the total yarn produced for the carpet in terms of volume and price. Therefore GNI will go up by more than 30% (even 60 per cent). For the UK, the carpet can be sold at a 30% to 40% higher price so GNI will go up by that level. A nanotechnology application that extends the life of a product is an example of a 'golden bullet', popular with those who hope that current environmental concerns will be solved by technologies allowing present consumerism to grow unchecked. Some commentators would cast doubt on this hope: clothes are currently discarded before the end of their natural life, so using carpets to the end of their extended life would require a new attitude; a novel application of this type might well inhibit recycling of used carpet.

Reducing the rate at which we wash clothes is beneficial

The application of 'smart technology' that halves the number of washes in the life cycle of the T-shirt is also beneficial – as for this product the use phase dominates the life cycle. We have assumed that the introduction of an 'easy care' process during the finishing stage of production (a chemical treatment) will double the energy consumption for this process. Despite this, the benefits from the 50% reduction in laundering will reduce the overall environmental impact by 15 to 30% depending on the category.

One limitation of the analysis is that there is as yet very little evidence available about the environmental and health impact of nanotechnology, so the toxicity impact of the 'easy-care' process has not been included. However given the toxicity profiles presented earlier it is likely that the toxicity impact of conventional cotton growing and harvesting would still dominate. For an organic T-shirt the toxicity of the imagined nanotech treatment would be proportionately more significant.

For the end-consumer, the effect of reducing the number of washes will be to reduce the need for electricity, water and detergent. The market for laundry detergents in the UK has been over supplied for the past 10 to 15 years, so laundry liquids are sold at similar prices to 20 years ago and about 80% of all laundry liquids are sold at a discount [H15]. The consumer will therefore see little benefit from washing less, despite rising energy prices [H16].

We assume that the Smart coating is applied in China, increasing the value of production in China, with similar effects to those described for the carpet above.

Consumer attitudes to new technologies

This theme raises the possibility that significant changes could be made in the sustainability of the clothing and textiles sector through changes in material sourcing and technology innovations. But, would UK consumers want to adopt these changes?

Attitudes towards green products

Interest in the environment among UK consumers has been growing in recent years and more people are becoming aware of green alternatives to regular products [H17]. However, just by looking at the product, it is difficult to see whether a T-shirt has been made from conventional or organic cotton, or dyed with non-toxic or harmful dye-stuffs. Therefore a class of labels is being introduced with requirements which manufacturers must meet before they can call their products 'green'. For example: Organic certifications from the Soil Association and regional and global eco-labels may be shown on products that meet these requirements [H18]. Widely recognised eco-labels are helpful guidelines for consumers who want to buy eco-friendly products.

Attitudes towards smart functions

New materials will not be embraced by all consumers. There is increasing discomfort among UK consumers about 'scientifically proven' innovations – and resistance to GM crops rests as much in an emotive lack of trust as with examination of scientific evidence.

In addition, Smart clothing and textiles have intelligent properties, but are more expensive than regular clothing. A trade-off exists between paying (a bit) more for a product that claims to last longer, and paying the same price for a product of familiar quality. Some people do not have a choice about wearing smart clothing: for protective clothing during their work, or sports that require breathable but strong fabric. The smart clothing market has grown significantly and is broadening its scope after having proved its value in these specific areas. In order to provide confidence in the claims made for new technologies, some carpet manufacturers, for instance, offer ten year wear warranties.

DO ECO-LABELS HELP CONSUMERS TO MAKE ENVIRONMENTALLY WISE DECISIONS?

An eco-label identifies the general environmental performance of a product within a product group based on its whole life-cycle in order to contribute to improvements in key environmental measures and to support sustainable consumption patterns. Government, industry, commercial associations, retailers, companies and consumers are all major participants in the scheme.

Participation in an eco-label scheme is voluntary; companies submit their products for third party compliance testing and/or verification to obtain an eco-label award for particular products that meet detailed established environmental guidance criteria [J12].

For the International Standards Organisation (ISO) the goals of these labels are to:

- Promote the communication of authentic and verifiable information on environmental aspects of products and services.
- Encourage the demand and supply of products and services that cause less strain on the environment.
- Invigorate the potential for market-driven constant environmental progress.

When the product is approved, permission to use the scheme's distinctive **eco-label 'Flower'** symbol is granted for a specified period. The award is periodically reviewed to ensure that standards are in line with new criteria, technological developments and market advances.

Some examples of the criteria to meet in the categories researched are:

- **Textile products** should contain limited amounts of substances harmful to health and the environment and should be processed with reduced use of water and air pollution [J13].
- **Laundry detergents** should not contain certain substances, should have limited effect on the growth of algae in water; be mostly biodegradable; and include ecological washing instructions [J14].
- **Washing machines** should limit detergent consumption and reduce energy and water consumption and noise. They have a life time extension guarantee with a take -back policy after use, and can be disassembled and recycled [J15].

The Oeko-Tex 1000 International Standard [J16] and the **Bluesign®** International Standard [J17] are examples of labels attempting to give clear information on the impacts of textile products.

Key points from the analysis of this theme

By exploring of the impacts of new products and materials we have learnt that:

- The extensive use of pesticides in conventional cotton crop growing is a major environmental issue. Using organic cotton would significantly reduce the life-cycle toxicity of cotton products. The analysis therefore suggests that recycling or reuse of cotton product (in order to reduce the demand for new virgin fibres) would have great value – not for energy saving (as with synthetic materials) but to reduce the use of toxic chemicals.
- The value of nanotechnology, or 'smart functions', depends on whether it acts to reduce the dominant impacts of a product's life cycle. In both cases examined in this theme, this was the case – the use phase of the cotton T-shirt and the production phase of the carpet – and correspondingly such technologies have great potential for reducing overall impacts. Their adoption, once scientifically proven, will depend on consumer trust and acceptance.
- Substituting natural fibres for synthetic fibres may be a useful move. In the case studied here, substituting wool for polyamide in carpet production, we found a significant benefit in the general environmental indicator, but a slight worsening of the climate change indicator.
- All four changes considered in this theme lead to higher priced products for the UK consumer. For the two cases with nanotechnology, we have anticipated development of new applications that would give an obvious benefit to the consumer, so could be brought to market under normal conditions. Adoption of organic cotton in clothing, and increased use of wool (as opposed to polyamide) carpet, depends on consumers asserting that they will pay more for a more 'ethical' product. Some evidence is developing that this is a likely and growing trend.
- The toxicity impact of other chemicals used in the production of conventional cotton is not significant compared to those used in agriculture.

Influence of Government decisions on the sector

The global clothing and textiles industry has been shaped by international agreements, quotas, subsidies and tariffs. These have strongly influenced national development of clothing and textile industries and the global flow of products. In this theme, recent major global agreements on clothing and textiles are reviewed. The future of the sector is then explored assuming further movement towards unrestrained trade. Some examples are given of improvements triggered by global awareness and by legislation.

Trade agreements

Before 1 January 2005 the international textile market was regulated by two major trade agreements – the Multi Fibre Agreement (MFA, 1974 to 1994) and the Agreement on Textile and Clothing (ATC, 1995 to 2005). The MFA existed from 1974 until 1994 imposing quotas on the export of certain textile products from developing to developed countries. The quotas were applied to trade in textiles and garments made from wool, cotton and synthetic fibres. The quotas were implemented to protect industry (and jobs) in developed countries from low cost competition from developed countries. As production in developed countries is more capital intensive, some estimates assess the effect of protecting a single job in industrialised countries to be the loss of 35 jobs in developing countries [K1].

The ATC, agreed during the Uruguay Round negotiations of the General Agreement on Tariffs and Trade (GATT) in 1995, aimed to encourage free trade and prepare for phasing out quotas on trade in clothing and textiles. As agreed in the ATC, quotas were phased out by 1 January 2005, but unrestrained free trade is yet to occur. Firstly, new "anti-dumping" and safeguard measures have been made available to importing countries. The admission of China to the WTO (World Trade Organisation) was partially agreed by accepting an extension of quotas to be applied until 2008, and even this period may be extended. Secondly, import tariffs are still being applied by developed countries at an average of 12% of garment import prices. Thirdly, other trade agreements including Dominican Republic Central America Free Trade Agreement (DR-CAFTA) and preferential trade agreements such as African Growth and Opportunity Act (AGOA) [K2] offer tariff free access to markets and in some cases impose labour standard requirements. Trade agreements give preferences to some countries, the members, and not to others, the non-members. It promotes trade within the free trade area, but disadvantages non-member countries by for example charging high import tariffs [K3]. Fourthly, quotas are imposed on non-members of the WTO [K4]. Finally, subsidies from the government are still paid to cotton farmers in the USA. These subsidies distort global cotton prices, as relatively high cost cotton from the USA is artificially cheap [K5].

Since the ending of the ATC on 1 January 2005, trade in clothing and textiles has been less restricted than before. What would happen if restrictions are further removed to the point of true free trade? To answer this question, we present here a summary of recent reports and analyses by the WTO, government and non-government agencies, industry groups and academics.

Free trade is unlikely to change production location

Production is conducted in the countries that have a competitive advantage in this field of production. For example, high quality cotton for the T-shirt is grown and harvested in the USA. The USA is known for providing high quality cotton at a low price [K6]. The USA might loose its competitive advantage for cotton crop growing in the long term if all subsidies are banned and cotton farmers do not lower their prices accordingly. However, due to their highly automated production systems (not to be found in Africa for example [K7]) USA cotton farmers may still be able to compete and keep their prices relatively low.

Since 2005, market share of both India and China has increased [K8]. According to WTO research of Nordas (2004) [K9], both China and India are countries with a revealed comparative advantage in clothing and textiles. Bathra and Khan (2005) argue that in terms of textile yarn, fabrics, made-up articles and related products and articles of apparel and clothing accessories, China and India have a complementary rather than a competitive relationship. It is unlikely that production shifts from one place to the other; rather they sustain each others industries, sourcing from one country to the other [K10].

In the base case cotton fabric and T-shirts are manufactured in China. China has a relatively good infrastructure, the capability of lean manufacturing, consistent quality and low costs, short lead times and access to important full-package suppliers in Hong Kong and Taiwan. These countries deliver China good, consistent quality in time at reasonable costs. The newest machines are used for the production plants [K11]. Chinese firms are said to master the Customer Relationship Management (CRM) model well by offering timeliness, consistency and quality. China has diversified to textiles, accessories and other inputs like fabrics, which gives buyers even more sourcing opportunities. Next to being an important supplier China has an enormous potential market for textile products, making it attractive for companies to invest in manufacturing plants there. Because of this potential it is unlikely that production will shift elsewhere [K11]. Despite this favourable position China is not invincible. Nordas (2005) states that other Asian countries, India, Indonesia and Vietnam, are catching up with China in terms of favourable unit labour costs. The Chinese industry is still weak in design and fashion capabilities, producing more reactively. There are signs that other Asian countries will catch up eventually [K9].

In the base case of the blouse, viscose fabric and blouses are manufactured in India. Batra and Khan (2005) say that India has a comparative advantage in numerous commodities, woven fabrics and textile articles being two of them [K10]. India is said to have suffered from its own government protection. For example, its clothing and textiles industry was restricted by export quotas on cotton to ensure that the domestic clothing industry had access to cheap local sourcing and only small scale production was allowed. India is lagging behind China because of outdated technology. Some governmental restrictions have been abolished recently and companies are now allowed to increase their production scales, making lower cost production possible. After the government deregulated the clothing and textiles industry in 1985 India's textile and apparel sector firms were encouraged to export and absorb new technology. The Indian government's investment in the clothing and textiles industry led to capacity increases and technical modernisation. Import taxes on synthetic fibres have reduced significantly, giving apparel firms access to more resources [K9]. It is unlikely that production will shift away from India, since government support has made the country ready for global competition.

Competition from developing countries in Africa is not expected to be severe: phasing out of quotas has already cost Africa over 250,000 jobs [K12]. Asian countries have invested in Foreign Direct Investments (FDIs) in Africa because it was inexpensive. These investments were encouraged under the Lomé Act, but after its abolishment interest in African FDIs diminished [K13]. Africa still enjoys several protectionist agreements from the AGOA. For example, Lesotho can now import Asian fabrics cheaply, process them in Lesotho and sell garments and textiles duty-free to the USA. The expiration of AGOA in 2007 forms another challenge. The question is not when competition becomes stronger, but more how Africa's industry will survive. Specialising in organic cotton and establishing vertically integrated firms are opportunities mentioned for the African clothing and textiles industry [K7] [K13].

The carpet is a different case. The actual production of the carpet is localised in the UK. Only a few components, polyamide and polypropylene, are produced abroad namely in the USA. When trade barriers are entirely removed production of some of the components can shift elsewhere because it is cheaper. For supplies of cheap materials low cost Asian countries (Bangladesh, India, Korea, India) could form a threat [K14]. During the quota phase out period between 1995 and 2002 intra-EU trade has dropped from 61% to 50% and external suppliers like Bangladesh have become more important [K9]. The trend towards an increase in external suppliers for the EU might continue. Concerning the production of the carpet, the biggest carpet producer in the world (Interface) is based in the UK. Although the

UK possesses the right production technologies and infrastructures, it could be that a UK based carpet producer starts to out-source part of production to lower cost countries because it is cheaper to produce there. However the money earned by these Foreign Direct Investments would be part of the Gross National Income that includes money earned by UK companies abroad. Out-sourcing part of the production will have a negative impact on employment in carpet production for the UK [K15].

USA subsidies of cotton are declining

Subsidies are any form of financial assistance offered by a government to a company or group of companies [K16]. Export subsidies are forbidden under the WTO Agreement. Other subsidies are forbidden if they are proved to harm an importing country's industry. As a solution, duties can be applied or an agreement can be signed stating that the price may not be lower than a certain level. Developed countries would want to protect themselves from cheap (subsidised) imported clothing from developing countries. Developing countries on the other hand are against the USA agricultural subsidies because they create unfair competition. According to Oxfam the solution is not to impose import levies, but to ban USA cotton subsidies [K17].

Cotton farmers in the USA have been highly subsidised for years by both the private and public sector [K18] allowing them to sell good quality cotton at relatively low prices while continuing to be profitable. These subsidies are widely criticised for creating unfair competition, for example to African and Brazilian cotton farmers [K19]. Unsubsidised developing country farmers are unable to export cotton at competitive prices, even though such exports would have significant developmental benefits to these countries. According to Oxfam's Make Trade Fair policy advisor Gawain Kripke, "Trade distorting subsidies are not only unfair, they are illegal" [K20]. Cotton subsidies distort trade. Actually, one can argue that the USA is dumping products, selling cotton under the market price of cotton. Brazil is a country that contested these subsidies with success; under WTO pressure USA cotton subsidies had to be lowered. The USA has agreed to lower subsidies, but still the private sector and also the government itself are subsidising [K21].

However, at present UK consumers are beneficiaries of USA subsidies – as they hold down the world price of cotton, so we can buy cheaper clothing. The World Bank has estimated that removing USA cotton subsidies will increase world market prices by around 13% [K22] – as other exporting countries compete to deliver attractive, but unsubsidised, prices.

USA cotton subsidies

Price in USD per kilogram*	
Cotton market price	$1.21
Cotton subsidies	$0.33

* Estimated per kilogram in 2004 [www.cottonlook.org; www.ewg.org]

As international quota agreements have been phased out USA subsidies have also begun to decline under pressure from several countries claiming the subsidies create unfair competition. The USA is alleged to sell good quality cotton under the current market price [K23]. Between 2003 and 2004 USA's cotton subsidies dropped by more than one billion USA dollars. At the same time export prices of USA cotton were dropping. Export prices are discounted by subsidies, but subsidies have gone down. This means that the actual price has dropped more than the drop in subsidies. This indicates that USA cotton farmers are able to drop cotton prices. Clearly a complete removal of cotton subsidies would make survival more difficult for USA cotton farmers, although it would also relieve USA tax payers of the cost of the subsidies. USA farmers would need to innovate significantly to keep their prices below those of such countries as China, India and Pakistan [K14] which have inexpensive labour and have begun to develop vertically integrated production from cotton crop growing to sewing a T-shirt all within the same country.

Ending quotas has increased EU imports from China and India

Countries that fully used their quotas under the MFA and ATC are expected to benefit most from their removal since they have not completely used their exporting capacities. Even with temporary quotas imposed on China, Chinese clothing and textiles exports to the EU and USA have grown significantly. Chinese factories have become larger and have driven down costs from economies of scale [K11]. The full elimination of quotas will, at least in the short term, encourage even more growth.

To date, the clothing and textiles industry in India has grown less than that in China since the phase-out of quotas [K9] [K11]. When exports from India were restricted by quotas, the country specialised in serving its domestic market and was characterised by very small companies, often home based. As a result, India's overall clothing and textiles productivity has been limited by technological obsolescence, low scales of operation and rigid labour laws. However, this home-based specialisation may now provide a new competitive advantage. Production in India is characterised by flexible, small batch production and customised mass production, which are well-suited to meeting current demand for higher quality customised goods, in small batches with short lead times [K24].

Unrestricted free trade can harm Least Developed Countries

Least Developed Countries (LDCs) such as Bangladesh and Sri Lanka experienced some restrictions during the MFA era, but benefited from the fact that larger competing neighbours (China, India, Pakistan) were restricted more. As a result, the textile industry in these countries flourished under the MFA. Bangladesh, for instance, enjoyed free trade of clothing into the EU and developed significant production capability in knitting and sewing [K25]. The country was therefore one of the largest suppliers of T-shirts to the EU.

Without the protection offered by quotas, LDCs face increased competition. Bigger textile economies

THE BANGLADESHI CLOTHING AND TEXTILES INDUSTRY IN A GLOBALISED WORLD

The 'Ready-Made-Garment Industry' (RMG) in Bangladesh has grown from practically nothing since the 1970s, increasing by 20% per annum [L1]. Despite concerns before the ending of quotas in 2005, the RMG industry in the post MFA world has not declined; the country has remained a successful producer and exporter of low-value basic items of clothing and is positioned among the leading garment exporting nations of the world. The clothing industry in Bangladesh is now the country's biggest export earner representing 76% of export income. There are over 4,200 garment factories, many of which have moved up the production chain to higher value items [L2]. Even though Bangladesh is a 'distant production platform' country, the USA followed by the EU constitutes its main markets and buy 96% of its knitwear and woven apparel [L2].

The Bangladesh textile and garment industry faces two major challenges. Firstly, the removal of MFA quotas brings opportunities to expand market share but also brings tough competition, which will be most severe when China's quotas are fully phased out in 2008. Key factors that have to be addressed to strengthen the competitiveness of the Bangladeshi clothing and textiles industry include: the unreliable and inadequate power supply; export diversification; image building such as marketing and branding; lead time reduction; quick access to a supply of raw materials; fast logistics; availability of bank loans; environmental reforms to address water pollution and waste management [L2] [L3].

Secondly, working conditions for workers in the clothing and textiles sector are generally poor. The 'National Garment Workers Federation' in Bangladesh (NGWF) represents and supports garment workers. It aims to ensure that workers' fundamental rights – such as fair wages and basic needs – are covered and acknowledged. The NGWF also negotiates with the government, demanding that it regulates the impact of future trade agreements in a growing and unstable industry.

In Bangladesh as in other EPZ (Export Processing Zones), the wages of the garment workers are fixed below the country's standard manufacturing wage. While the national minimum wage is US$20 per month, the clothing industry workers monthly wage is set at US$14 [L4]. A ready supply of low-skilled labour, along with a very low standard of living, allows the garment wage to be kept at a low level. This low labour cost plays an important part in the competitive advantage Bangladesh has over their competitors in the clothing and textiles sector.

According to studies by the Bangladesh Institute of labour studies (BILS) [L5] and The 'National Garment Workers Federation' in Bangladesh (NGWF) [L6], employees often:

- Have to work 14 to 16 hours per day, sometimes being forced to work during the night and seven days a week.
- Do not receive their payment on time, sometimes more than two months late.
- Are denied the right to join a union.

According to reports from Labour behind the labour LBL [L7], Oxfam [L8] and Ethical Trading Initiative ETI [L9]. Bangladeshi clothing and textiles workers are also exposed to low safety standards. Problems such as faulty electric wiring, unsafe buildings, locked or blocked emergency-exits and in one case, a single narrow staircase to evacuate over a thousand workers, have led to several factory disasters. As a result approximately 350 workers have been killed and 2500 injured since 1990.

Employees and citizens have reacted to these circumstances with disruptive protests and demonstrations. Most recently (June, 2006) workers have demanded a 30% rise in their salary. A memorandum of understanding has been signed by government and industry bodies, promising employees new rights such as paid days off, union participation and a new wage to be announced within three months [L10]. Bangladesh is trying to reassure USA and EU buyers that the violent protests hitting the garment industry are now under control. Failure to conform to international social and labour standards could undermine competitiveness.

where many companies produce higher volumes and greater variety of clothing and textiles products are more attractive for importing countries. According to Oxfam, major income and job losses were expected for these countries after the removal of quotas on 1 January 2005 [K26]. Africa has been suffering over 250,000 job losses during the quota removal period [K12]. The Bangladesh clothing and textiles industry has been unexpectedly flourishing after the quota removals in 2005 [K27]. In China, being more developed, employment in clothing and textiles has grown from 14 million in 1995 to 19 million in 2004.

Globally, a trend of growing sales is observed in the clothing and textiles industry. At the same time, due to increased efficiency in capital use and consolidation of the industry, the number of employees in the clothing industry worldwide has dropped from 14.5 million in 1990, to 13.1 million in 1995 and 13.0 million employees in 2000. For textiles global employment declined even quicker: from 16.8 million in 1995 to 13.5 million in 2000 [K28] (UNIDO data 2005).

Preferential trade agreements currently distort free trade

Preferential trade agreements (PTAs) require member countries to award tariff reductions to each other that are not granted to non-members [K29]. A bilateral trade agreement, a type of preferential agreement between two political entities, can include agreements on custom unions, free-trade, association, co-operation and partnership [K30]. A customs union promotes free trade for member nations and sets common tariffs to non-member nations. Currently, about 250 regional trade deals exist and many new agreements are being negotiated [K31]. Celine Charveriat, Head of Oxfam International's Make Trade Fair campaign states that "Free trade deals in the form favoured by the EU and USA pose a considerable threat to developing countries. Having caused the breakdown of Doha rich countries are now competing to gain better access to developing country markets through regional deals that only serve their interests." The Doha Round negotiations were meant to discuss issues raised by developing countries about the implementation of current WTO Agreements [K32]. WTO members promised to be conscientious with the implementation of anti-dumping safeguards to developing countries. However, Oxfam for example is critical of this, stating that these negotiations failed developing countries.

Developing countries are said to have less bargaining power; important issues like trade distorting agricultural subsidies are for example not addressed in trade arrangements [K31]. Free trade arrangements are said to mainly limit poorer countries' opportunities at the time when most quotas are banned. Mexico for example saw its imports of subsidised USA rice and wheat more than triple since the 1994 NAFTA. High agricultural subsidies in the USA enable USA farmers to sell products at a low price. This selling price is often under the current market value. USA farmers can sell their good quality products at very low prices, causing unfair competition for Mexican farmers [K17]. This has devastating effects on farmers and their families [K31].

Localisation

One trend facilitated by the end of quota agreements, but counter to the concentration of production in China, India and Pakistan, is the rise of localised production – driven by retailers' needs to chase fashion trends very rapidly. A prominent example of this approach is the Spanish company Zara whose success is based on speed, flexibility and innovation. Manufacturing in Spain and Portugal adds a cost premium to their products, due to higher labour rates. But, this localised production allows Zara to respond to consumer trends more rapidly than competitors while also avoiding expensive discounting of end-of season clothing stocks [K33]. Having production closer to the point of retail, and organised in many small units, allows flexibility and responsiveness, without incurring charges for air-freight as would be required from Asia. Other drivers for localised production include regional trade agreements, such as DR-CAFTA which aim to facilitate sourcing of goods from geographically closer regions by dropping tariffs [K34], and the strategy of some producers to retain production bases in their home country to avoid becoming too dependent on a single source country [K35].

Tariffs to prevent "dumping"

Tariffs are a strategic means to control the imports of goods into a country. They have been used in the past (1820s) by industrialised countries like the UK to promote growth of domestic manufacturers. In 1932 the UK reintroduced tariffs because of competition from Germany and the USA. More recently, Vietnam and China have used tariffs as a development strategy. China had average tariff rates of about 40% until they were dropped and Vietnam continues to apply this rate [K22].

Since 1996 USA, European, Japanese and many other countries' clothing and textiles import prices have fallen as trade barriers have been removed – and producers with excess capacity have competed for market share. 'Anti-dumping' rules are set to prevent countries from exporting products at less than the price at which they are sold domestically. Manufacturers in the USA and Europe are keen on such anti-dumping safeguards as protection for their own markets from what they claim is unreasonable competition.

A recent example of dumping occurred with low priced shoe exports from China and Vietnam. In August 2006, the European Commission tried to implement a formalised system of import duties to prevent Chinese shoes being dumped. Shoes from China and Vietnam were alleged to be sold at a price below their cost, made possible by government subsidies. The EC proposed 16.5% duties for Chinese imports and 10% duties for Vietnamese products. Italian, Portuguese and Polish shoe makers would welcome protectionism for fear of losing their jobs due to low priced imported shoes [K36]. At the beginning of October 2006, the EU agreed a two-year shoe tariff deal. This gives some relief to shoe manufacturers within the EU, but leads to frustration for footwear brands which have switched to manufacturing in China.

The sector is becoming more capital intensive

The clothing and textiles market is likely to become more concentrated: smaller firms will face increased pressure as the main importing countries focus on bigger suppliers [K5 K28]. Meanwhile, growth in the demand for clothing is expected to slow down in Europe, the USA and Japan, but new markets are anticipated in higher income South-East Asian countries and in middle and higher income groups in poorer countries.

Developing countries have specialised in exports of clothing and textiles as the more industrialised countries have switched to other products. According to the ILO [K5 K28], the greatest rise in employment was in China between 1995 and 2004, but the textile industry is not China's main source of employment. Whereas total manufacturing employment in China is around 19%, it is around 35% in Bangladesh, 44% in Madagascar and 43% in Pakistan. ILO analysis shows that for China, Pakistan, Cambodia, India, Guatemala, Romania and Turkey textile employment has become more important, whereas in Sri Lanka, Bangladesh and Africa (except for Madagascar) it has declined. The consolidation of the industry and more intensive use of capital equipment led to a small worldwide reduction in textile employment from 13.1 million workers to 13 million workers during the phase-out period of the MFA, between 1995 and 2000, during which time global demand grew. At the same time, the proportion of women working in the clothing and textiles industry is growing. Among various countries with important textile industries the quality of employment in the clothing and textiles industry compared to the manufacturing industry as a whole is reported by the ILO to be low. The average textile wage as a percentage of the average manufacturing wages has worsened. According to the World Bank, job losses are expected in vulnerable countries. Furthermore, the Bank anticipates that unless the link between workers' welfare and productivity is addressed actively consolidation of the sector will lead to deterioration in labour standards and working conditions [K37].

Free trade can thus have some less desirable effects – allowing concentration of the sector under fewer owners, and leading to the loss of clothing and textiles jobs in countries for which the sector is a significant

REACH: THE NEW CHEMICALS LEGISLATION AND THE CLOTHING AND TEXTILES INDUSTRY

The world textile chemical industry is worth over US$15 billion [L11]. Its products include pesticides, colorants, auxiliaries, coatings, sizing agents, finishing and preparation chemicals, detergents printing pastes and dyes. They are produced and consumed all over the world and applied in most phases of the clothing and textiles manufacturing process, including yarn and fabric manufacture, apparel, home furnishing, carpets and rugs, industrial and technical textiles.

More than 100,000 chemical substances are part of our daily lives, yet trustworthy information is not available for about 75,000 of them [L12]. Although created with the aim of contributing to the improvement of living conditions, a considerable number are toxic and may cause irreversible damage to the environment and to the health of workers and consumers. Some chemicals used in the clothing and textiles industry have proved to be disruptive to the endocrine system or carcinogenic [L13]; others can initiate asthma and allergies or cause serious alterations in fertility and neurological behaviour [L14]. These toxins are present within the products we wear and use everyday [L15]. Some are biologically persistent, degrade slowly and are widely spread via wind or water; their production and user phases generate CO_2 emissions that contribute to global warming, pollute water effluents and create waste residues that do not biodegrade [L16].

REACH – the "Registration Evaluation and Authorization of Chemicals" – is an EU program to update and improve the current legislation on chemical substances and regulate their manufacture, import, marketing and end use. The EU began chemical legislation in 1979 with a safety test for new chemicals. However, an exemption was made for all chemicals already on the market by September 1981. There are about 30,000 of these "existing chemicals" on the market today. The REACH program is designed to ensure that chemicals are safe for human health and the environment. It will make no distinction between "new" and "existing" substances and will collect information on, analyse and register all industrial chemicals [L17]. A final decision about the REACH programme will be taken by the EU by the end of 2006 [L18] and the legislation is expected to be applied from 2008 onwards.

fraction of exports. Furthermore, freer trade may also lead to opportunistic and rapid shifts in production orders between companies and locations, increasing the vulnerability of the many temporary workers employed in the sector. However, freer trade can give developing countries more opportunities for growth, at least when protective measures such as the USA cotton subsidy are banned.

CORPORATE SOCIAL RESPONSIBILITY: SMOKE-SCREEN OR PRACTICAL REALITY

Globalisation of clothing and textiles production has made it more difficult to regulate standards with regard to labour conditions and environmental impacts through a 'single country policy' as companies are increasingly sourcing from many different overseas suppliers. The development of Corporate Social Responsibility (CSR) programmes in developed countries has occurred in response to increasing consumer interest in social and environmental impacts of business activities wherever they operate in the world. The importance of CSR has also been promoted by groups such as The Corporate Responsibility Coalition (CORE) [L19].

"CSR covers a wide range of voluntary business activities that improve the social and environmental performance of companies and sharpen their competitive edge" [L20]. Throughout the textile and apparel industry CSR practices are increasingly recognised and supported by governments, national and international organisations, NGOs, retailers and manufacturers. Some outstanding examples are:

- Governments: the AGOA (African growth and opportunity act) [L21] is a preferential duty-free access trade agreement signed between Sub-Saharan African and the USA.
- Organisations: The "Better Factories" agenda in Cambodia, implemented by the ILO (International Labour Organisation) working in collaboration with the government and their customers in Western countries aims to create services, support, monitor and report on working conditions, while at the same time enhancing quality and productivity [L20 L22]. Another example of CSR is the MFA-forum [L23] programme in Bangladesh and Lesotho; working with the Ethical trade initiative [L24], Fair Labour Association, Social Accountability International and others [L20 L25].
- Buyers and retailers: Marks and Spencer through their 'Look behind the label' program [L27], Gap Inc. with a similar measure [L26] and many other ETI members [L28] are promoting CSR compliance as a prerequisite to doing business with suppliers. Buyers assist suppliers by carrying out 'responsible purchasing' in which they establish long term relationships, share risks [L29], identify suppliers areas of concern and communicate clearly their codes of conduct so suppliers can start working on their own solutions to address environmental and social issues [L20].
- Manufacturers and suppliers in different countries like China [L30], Sri Lanka, Bangladesh, Morocco, El Salvador and Lesotho's garment and textile sector, have addressed CSR as a strategy to strengthen their industry competitiveness in the globalised world; especially the Cambodia garment industry that has been recognised as an ethical sourcing supplier [L20 L31].
- Studies and campaigns by International organisations and NGOs such as Oxfam and the Clean Clothes Campaign [L32] have been important drivers in promoting CSR codes of conduct in the sector. Buyer initiatives and consumer concern have also increased interest in "ethical fashion" and fair trade [L33]. "A survey commissioned by Marks and Spencer revealed that almost a third of shoppers had put clothes back on the rails amid concerns about their origins. It also found 78% of shoppers wanted to know more about the way clothes were made, including the use of chemicals and conditions in factories producing the goods" [L34].

CSR practice can be put into operation in many ways [L35]:

- Work place codes to protect workers rights for fair hours of work, pay, vacation and sick leave, to increase diversity and opportunity, to avoid discrimination and to ensure safe working premises [L30].
- Improved management systems for instance through increased stakeholder engagement, shared decision making and employee involvement.
- Business ethics through developing a consistent approach to legislation on social and environmental issues or by adopting standards (such as those of the Ethical Trading Initiative or SEDEX [L36] the Supplier ethical Data exchange).
- Use of sustainable raw materials, products, technology and energy such as crops that employ no pesticides or have reduced need for water, use of materials made from renewable resources with 'alternative-green' substituted chemicals [L37] and the use of renewable energy.
- Transportation and waste management for instance, reducing waste by improved design, or choosing materials that can be recycled or are biodegradable.

Improving environmental and social performance

A benefit of the opening-up of markets has been an increased global awareness of poor labour practices and environmentally damaging actions in some parts of the global clothing and textiles industry. This awareness has in some cases led to development of new ethical and environmental standards. Eco-labels, which aim to set environmental standards for products assessed by governmental bodies, may in fact become the new trade barriers – whereby retailers and consumers in developed countries can enforce standards on their suppliers. There is some concern that eco-labels could be used as unfair trade barriers, since the standards often favour the current standards of the imposing territory (for example the EU) and therefore give an advantage to internal producers [K38]. However, the opportunity to use such labels to bring about social and environmental improvement is attractive – even though the change is likely to lead to higher consumer prices. The REACH legislation discussed in the box is an example of a chemicals directive in the EU. At an industry level companies are increasingly developing ethical standards for good practice. They are at least partially driven by negative publicity and campaigning and are concerned to ensure that realistic standards are achieved in practice.

Key points from the analysis of this theme

From exploration of the impacts of 100% free trade we can conclude that:

- For the three case study products considered in this report, the structures of production would be largely unchanged by a move to unrestricted trade. However, USA cotton would become significantly less competitive with the removal of subsidies, and some raw materials for the carpet might be imported to the UK.
- Removing subsidies will harm the competitiveness of USA cotton farming, in favour of countries such as India, China and Pakistan where it is possible to create a vertically integrated supply chain from cotton crop growing to sewing T-shirts. This process is already well under way.
- Unrestricted free trade will lead to lower prices for UK consumers, provided the industry does not become so concentrated that price fixing is possible.
- Unrestricted free trade was expected to be most harmful to less developed countries such as Bangladesh, where the clothing and textiles sector has been a major employer and a significant fraction of the country's export earnings. It seems difficult for developing countries to compete with China: despite similar low wages, the infrastructure and investment in China is greater and larger companies operate with some favourable government support. Bangladesh proved the exception, being now one of the leading global garment exporters.
- Freer trade may lead to freer flows of information, creating awareness of social and environmental problems created by the clothing and textiles sector.

Gathering the threads

The scenario analysis was restricted to three case study products and used simplified measures to attempt to gain a broad insight into the consequences of possible changes to the sector. Having completed the four themes, we attempt here to draw broader lessons from the focused analyses.

Some counter-intuitive results emerged from the scenario analysis

The price of a £7 T-shirt bought in the UK is made up of 22p of raw material (cotton), 33p of production costs in the USA in spinning yarn, 53p of production costs in China to knit and dye fabric and 88p of production costs in China to cut and sew the fabric into a finished garment.

Each time a UK consumer buys a £7 T-shirt, they in effect receive a payment of 6p from the government of the USA due to cotton subsidies.

Each one million T-shirts purchased in the UK has directly caused the employment of 22 people in the USA in agriculture and yarn manufacture, 234 people in China in weaving and finishing and 57 people in UK retail.

The population of the UK purchases approximately three billion garments per year equivalent to approximately 50 items per person.

The raw material costs of a finished garment are sufficiently small that much higher quality raw material (or more expensive raw material production) could be used without significantly affecting retail prices.

Despite the exit of manufacturing in this sector from the UK, it remains economically significant because of the size of clothing and textiles retail operations. If every business in a supply chain takes the same profit margin, the final business (retail) will have the highest turnover and correspondingly the highest absolute profit.

In several analyses we have seen that measures of environmental impact within the UK must worsen in order to make a global improvement. This is significant because the current focus of UK policy on UK measures is likely to lead to globally bad decisions, unless the measures are corrected to include 'embedded' impacts.

When a customer purchases a 250g cotton T-shirt they must also in effect purchase 1.7kg of fossil fuel to provide electricity for washing, drying and ironing. This will be released to air as 4kg of CO_2 emissions. During the period of owning the T-shirt, 125g of detergent will be sent to waste water processing. In disposing of the T-shirt, if it is incinerated, it will be reduced to 3g ash and the fossil fuel will leave 10g ash but these are small components of a total of 450g of waste sent to landfill, which is made up of primarily mining waste generated during extraction of the fossil fuel.

Fast fashion leads to fast landfill. Volumes of clothing purchased have increased by around one third in the past five years and a weight of clothing and textile equivalent to approximately three-quarters of purchases is buried in land-fill in the UK each year.

There has been almost no technology innovation in textiles recycling since the demise of the 'shoddy trade'. The shoddy process carded used textiles into short fibres by tearing, but there is great scope for invention of novel recycling processes that aim to extract longer fibres.

Is our quantitative analysis realistic?

The environmental indicators of the analysis were calculated using Life Cycle Analysis (LCA) – which is the internationally accepted tool for this type of calculation. A widely known problem with LCA is that it is only feasible if boundaries are 'drawn' around the problem being investigated, in order to provide a tractable problem. Such boundaries generally attempt to include all direct inputs to a product but exclude indirect inputs such as capital equipment and infrastructure. Estimates of how much this leads to under-prediction of impacts varies, but can be as high as 50% in some cases. So, the absolute values predicted in the LCA will be only partially accurate, but their relative accuracy – between scenarios where the boundary conditions are constant – should be high.

We have chosen to use three key indicators in our LCA related to the Danish EDIP methodology: climate change (measured in thousand tonnes of CO2 equivalent); waste volume (in thousand tonnes); an aggregate 'environmental index' representing the combined effect of ozone depletion, acidification (acid rain), nutrient enrichment (algae growth and can cause fish death) and photochemical ozone formation (smog). We could have chosen other LCA methodologies but selected the EDIP methodology because extensive textile related data sets were available using this method in the GaBi-EDIP software package. We could also have decided to include detailed life cycle analysis of the use of resources like oil, iron and aluminium etc. or included other indicators like land-use but decided to limit the analysis and presentation of results to only three indicators for reasons of simplicity. Climate change and waste were selected as key indicators because they have become common in the public domain in recent years. We also decided to create and use an aggregate 'environmental index' even though it is not directly recommended in the EDIP methodology. Because we are using the "Person Equivalent Targeted" (PET) unit for all the contributions to this indicator this is in principal mathematically correct and enables us to report major environmental changes in a more simple way.

Two issues arise in the very simple economic model used to predict macro-economic effects of the scenarios. Firstly, the analysis assumes that activity can be brought in and out of the UK independently of other activity there. In fact, most economists would describe the UK as having "Full employment" – so creation of clothing and textiles jobs in the UK would be possible only by replacing jobs in another sector. If this is the case, the analysis over predicts any positive changes to GNI – as the jobs are substitutes not new jobs. However, we have assumed that the jobs created would typically be relatively low skilled and that there is surplus labour in the UK for such tasks. Secondly, many economists would want to include a "multiplier effect" for predictions of GNI: someone who used to be unemployed but is now employed will spend their income, mainly within the country, which will in turn create new jobs and new national income. The difficulty of this type of analysis is to predict which multiplying factor to use. We have chosen here to ignore it.

Our social analysis has included a numerical prediction of employment and some qualitative discussion based on differences between countries. Naturally, the social consequences of any change in a production system are widespread, so much other discussion could be included. However, despite extensive discussion and reading, we were unable to find other numerical measures of social effects to include in our numerical predictions.

Can we extrapolate to other products in the sector?

The key results from the environmental analysis of the different products have been summarised by identifying within the product life cycle a dominant phase (raw material, production, use, disposal) where a given impact was most prominent. The success of various responses depends on how well they address this dominant phase and the likely cost impact of the response. This insight will spread across the sector – and to other sectors – as a means to identify where changes should be sought and applied.

Many other materials and sources of material could have been considered. For instance, we have chosen to examine cotton grown in the USA – which is typically among the best quality – but could have chosen cotton from Egypt or Uzbekistan. This would have changed our absolute numerical predictions of impacts, but had little effect on their relative proportions.

All of the products in our case studies were made entirely from pure yarns. Mixed material products made from multi-fibre yarns are more complex to

analyse, although again the approach of identifying key phases would be relevant. However, recycling such products would probably not be possible – due to the high costs of separating materials.

Conclusions

Weaving a new future

We've used the mass balance study to understand the supply of the UK's demand for clothing and textiles and the scenario analyses to show how changes in the way they are produced and used might affect the triple bottom line of sustainability. Now we can draw together the lessons learnt from these specific studies.

How should we build a more sustainable future for clothing and textiles in the UK?

A common thread through the scenario analyses has been the importance of the consumer in creating change in the sector. The mass balance study showed that three quarters of the flow of clothing and textiles into the UK is for domestic use, so the simplest action that would reduce the environmental impact of the sector would be for UK consumers to reduce the weight of clothing and textiles they purchase each year. For many of the specific options for change considered in the scenario analysis, we have also seen that they would develop more rapidly if driven by consumer demand.

Accordingly, we can now propose a model of "ideal consumer behaviour" that would drive beneficial environmental change in the sector. Almost certainly, at the time of writing, this behaviour would appeal to only a small minority of UK consumers and would have economic and social disadvantages elsewhere. So, having proposed our 'ideal consumer' we can then look at the barriers that oppose change and a means by which beneficial change could be brought about.

What would the 'ideal' consumer do?

In order to promote the best environmental and social performance of the supply of clothing and textiles, an "ideal" UK consumer would:

- Buy second-hand clothing and textiles where possible.
- Buy fewer but longer lasting garments and textile products.
- When buying new products, choose those made with least energy and least toxic emissions.
- Only buy products made by workers paid a credible living wage with reasonable employment rights and conditions
- Lease clothes that would otherwise not be worn to the end of their natural life.
- Wash clothes less often, at lower temperatures and using eco-detergents, hang-dry them and avoid ironing where possible.
- Extend the life of clothing and textile products through repair.
- Dispose of used clothing and textiles through recycling businesses who would return them for second-hand sale wherever possible, but otherwise extract and recycle the yarn or fibres.

If UK consumers chose to behave in this way, both government and business would follow their behaviour and provide the services and functions they demanded.

What are the barriers to this behaviour?

Apart from consumer inertia there are several reasons why the 'ideal' behaviour described above is not current. Barriers associated with consumer choices include:

- In a wealthy society, clothing and textiles are bought as much for fashion as for function, and the desire to appear fashionable promotes purchase of products before the end of their natural life.
- Longer lasting clothes made with environmental and social responsibility will cost more than those made without such consideration.
- UK consumers do not necessarily recognise the connection between their purchase and use of clothing and textiles and their environmental and social consequences.
- The benefit of the 'ideal' behaviour depends on collective not individual behaviour but it is much more difficult to create a mass changed of direction than to motivate a few pioneers.

Barriers associated with economic forces and government policy include:

- Reducing the rate of new clothing purchase would reduce the profitability of all businesses operating in the supply chain, reduce the national income of their host countries and reduce the number of people employed by the sector.
- UK government policy on the environment (and that of many other western governments) is focused on emissions within our own country. We have seen in several scenarios that this focus will lead to decisions that worsen global environmental impacts. Domestic policy must take account of 'embedded emissions' driven by UK consumption but occurring elsewhere.

Barriers associated with technology and infrastructure include:

- Repair is currently an expensive service in the UK.

The rapid rise of 'fast fashion' in the past five years has increased the flow of material in the sector, but with the expectation that garments will be worn fewer times before disposal. These garments may be less easy to repair than higher quality products.

- We generally wash clothes in order to 'freshen' them (remove odour) rather than to remove stains, but do not have a 'freshening' process other than washing – which is necessary for stain removal.
- Only around 15% of disposed clothing and textiles in the UK is collected for reuse and recycling at present, partly due to the relative ease of placing used clothing in a general rubbish bin rather than in a clothes bank.
- Sale of second-hand clothing in the UK is limited, partly due to the high cost of sorting collected clothing.
- Since the decline of the 'shoddy trade', almost no fibre recycling occurs in the UK and there has been virtually no technology innovation in this area for 200 years.

How might the barriers to change be overcome?

The four major stakeholder groups that can influence change in this sector are consumers, government, business (primarily retailers in the UK) and "information providers" (educators, campaigners, journalists and academics). Rather than trying to provide a prescriptive menu of actions for each group, we propose here a set of actions which would support a move towards the ideal consumer behaviour:

- For consumers, the motivation to take purchasing decisions based on environmental and social concerns is complex – as the consequences of an individual purchasing decision are relatively small and also apparently remote. **Consumer education** is therefore vital – to ensure that fact based information on the individual impacts of a product are made clearly available and then to support consumer understanding of the consequences of this information. Eco-labels are a step towards this goal – and development of well grounded information through eco-labels is a necessary step. However, in addition, consumers need support in understanding the link between a product's hidden use of resources and its consequent harmful impact – as seen dramatically in the Aral Sea, or as predicted with global warming. Such education can be funded by government, promoted by business and driven further by campaigners and educators.
- The complex set of interactions which contribute to 'fashion leadership' – by which certain styles are seen to be current – could actively promote **durability as a component of fashion**. The idea of 'design classics' is well understood and many of the cycles of fashion return to styles of the past. Increased emphasis on durable style would support consumers in moving towards purchase of fewer higher quality and longer lasting products.
- Halving the flow of existing products purchased in the UK would directly halve the employment and income generated by the sector. However, raw material costs in this sector are proportionately low, so if half the material mass was used to create half the current number of products, with higher quality material inputs and double the labour input for each item, the sector could halve its material flow without economic loss – provided consumers are prepared to **pay a higher price for a product that lasts twice as long**.
- **New business models** with growth in profit decoupled from increased material flow are possible where consumers pay for services – such as repair, novel coatings, other maintenance services, remanufacturing or 'fashion upgrades' – rather than for purchase of new 'virgin' material. 'Closed-loop' business models in which retailers take back end of life clothing, for instance, could promote fibre reclamation and so reduce demand for new materials.
- Clothing **repair** has largely disappeared in the UK, but could be actively developed: businesses could promote garments 'designed for repair' with new profit streams from repair kits or spare parts rather than new sales (as happens in the car market); new technologies could support rapid repair, to reduce the high labour cost of manual operations; new joining techniques could facilitate rapid removal and replacement of damaged components or sections.
- There is great scope for **technology development** to support a move to reduced impact: new means to freshen clothes without washing would be advantageous; technology for sorting used clothing would overcome the high labour cost of this operation in the UK; fibre recycling technology has had relatively little attention in 200 years and has significant scope – both for extracting fibres with less shortening and for fibre separation from blended products; ongoing development of detergents will allow further reductions in wash temperatures; novel coatings and smart functions may support increased product life and reduced need for care in use, although they may also impede material recycling; new longer lasting fibres would support durability.

- The **infrastructure of clothing collection** could be greatly improved – domestic waste sorting, which is growing in the UK, could allow separate collection of used clothing and textiles (as increasingly happens with glass and paper).
- An **eco-tax** on new product purchase could be used to slow the growing rate of material flow in the sector and fund development of technology, infrastructure and services for clothing and textiles recycling.
- **Legislation** could be used to outlaw specific undesirable components – such as particular toxic chemicals, but this would be difficult to impose on imports due to the complex range of chemicals involved.
- The UK's involvement in negotiating **international agreements on trade** could be used to promote environmental and social responsibility in supplier countries, while fairly acknowledging the economic consequences of imposing improved behaviour on otherwise cheap suppliers.

The key to change remains the behaviour of the mass of UK consumers (and voters) so the role of educators and campaigners in raising awareness of the consequences of consumer choices is central to driving change.

Have we learnt anything about other sectors?

In the introduction, it was mentioned that this report is – as far as we know – a first attempt to take such a broad view of a complete sector. Having done so, can we make recommendations about how to perform a similar study in other sectors? The report concludes with two brief responses to this question. Firstly, if we were to apply a similar approach to another sector, could we take any short-cuts? Secondly, even without a detailed study, can we predict the changes most likely to have a significant influence and anticipate responses to their economic consequences?

A guide to analysing change in another sector

The approach taken in this report has been to consider representative case study products and predict the 'triple bottom line' consequences of change in their delivery. In summary, our approach was:

- Identify the composition of the sector – the various companies and other sectors required for it to function – and understand the flow of materials and services through it.
- Use a Delphi study to understand the evolution of the sector – why the current production structure has emerged.
- Propose three representative case study products and gather data about their current production.
- Develop, from expert input, candidate scenarios for future forms of the sector, grouped in the themes: production structure, consumer influence, innovation, government influence.
- Complete an environmental, economic and social assessment of the consequences of each scenario for some of the case study products.
- Create a draft report on the scenario analysis and circulate it to stakeholders for feedback.

Broadly this approach appears to have met our needs and we would recommend it. However, we can also anticipate some ways to simplify our approach:

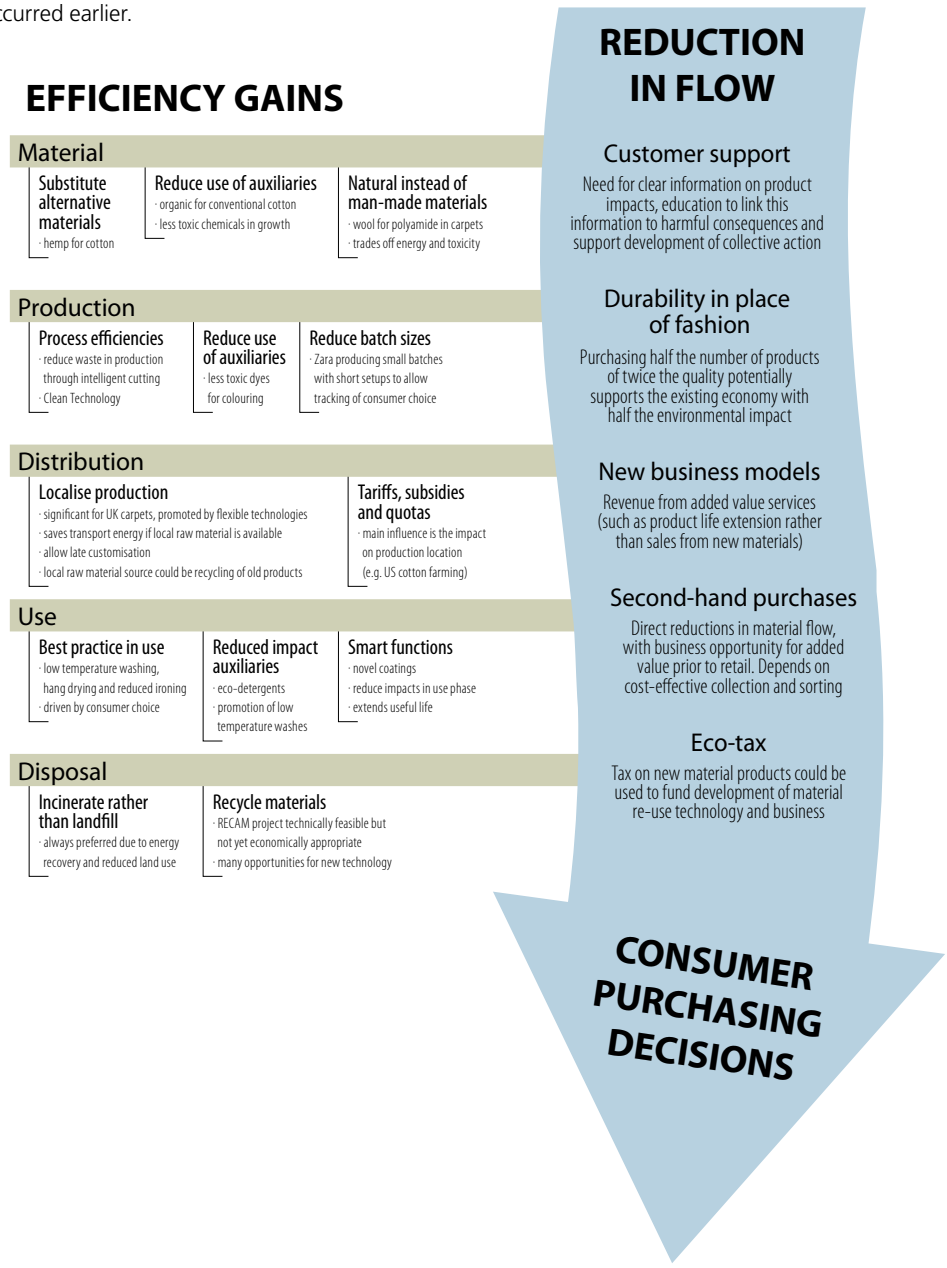
- In this report we predicted the environmental consequences of each delivery mechanism through detailed life cycle analysis. This is arduous, and in some cases almost impossible, where data on the composition of complex chemicals is unavailable. In fact, the main use we have made of the life cycle analysis has been to identify the major impacts of the product and to specify in which phase of the life cycle (material, production, distribution, use, disposal) they occur. The first of these uses could

probably be achieved through a sector expert – able to identify major environmental impacts for any product. The second, can then be achieved by a simplified analysis – once the dominant life cycle phase has been identified, this directs the search for relevant changes.

- The Delphi study approach to understanding the forces acting on the sector and its consequences, proved arduous. A similar quality of information could probably have been achieved more simply in informal discussion with a panel of sector experts – provided a suitably representative panel was gathered.
- We received extremely valuable feedback from many experts across the sector on the draft of this report. In retrospect, this is a crucial phase of the work – as the highest quality information is available in reaction to an analysis of the sector, which may challenge existing preconceptions. This component of the work could usefully have occurred earlier.

Anticipating the recommendations

The environmental impact of any sector will be reduced if the flow of material within it is reduced, but this may be economically harmful. For a particular product, its environmental impacts are likely to be predominantly associated with particular phases of its life cycle, so efficiency or substitution should be sought in this phase. In both cases, change would occur if driven by consumer (voter) behaviour, but even without this driver, it is possible to find means to overcome economic disincentives. The figure summarises the solutions we have explored in this report – and in concluding the report, we hope that this will serve as inspiration for those looking for beneficial change in other sectors.



Footnotes

THE WORLD OF CLOTHING AND TEXTILES

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B6 Calculated from DTI, 2006. UK energy sector indicators 2006, page 91.

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C1 Danish LCA-center web-site with information about the GaBi-EDIP software database and tool.

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LOCATION OF CLOTHING AND TEXTILE PRODUCTION

D1 Zensah is a company which aims to develop seamless knitted garments which do not necessarily have to have a close fit to the body, by loosening the tension of the yarns during the manufacturing processes.

www.zensah.com/.

D2 Stork prints group manufactures and supplies printing systems for fabrics and garments.

www.storkprints.com

BOX STORIES

E1 Examples of companies developing this technology are: Browzwear: developer of the V-stitcher solution (2005) which allows a preview of a true-to-life garment in a three dimensional view.

www.browzwear.com/

Stylezone: a website which allows you to create your own 'avatar' and create your own clothes design.

www.stylezone.com/

Gerber Technologies a distributor of V-stitcherTM

www.gerbertechnology.com/index.asp

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www.lectra.com/en/index.html

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www.santoni.com/

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