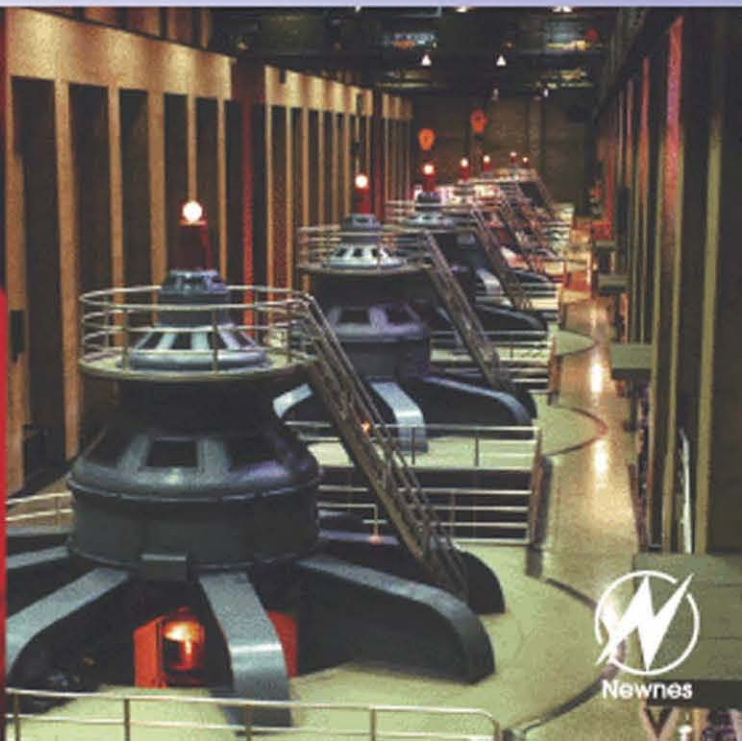
BTEC NATIONAL ENGINEERING

Mike Tooley & Lloyd Dingle



ELSEVIER

Newnes

BTEC National Engineering

This Page Intentionally Left Blank

BTEC National Engineering

Mike Tooley and Lloyd Dingle

Newnes

OXFORD AMSTERDAM BOSTON LONDON NEW YORK PARIS
SAN DIEGO SAN FRANCISCO SINGAPORE SYDNEY TOKYO

Newnes
An imprint of Elsevier Science
Linacre House, Jordan Hill, Oxford OX2 8DP
225 Wildwood Avenue, Woburn MA 01801-2041

First published 2002

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN 0 7506 51660

For information on all Newnes publications visit our website at www.newnespress.com

Typeset at Replika Press Pvt Ltd, Delhi 110 040, India
Printed and bound in Great Britain

Contents

Introduction

Welcome to the challenging and exciting world of engineering! This book has been written to help get you through the core units of the BTEC National Certificate and Diploma awards in Engineering. It provides the essential underpinning knowledge required of a student who wishes to pursue a career in any branch of engineering.

The book has been written by two highly experienced further and higher education lecturers. With over 40 years of practical teaching experience they have each contributed their own specialist knowledge which has been designed to cover the core units of the revised and updated BTEC Engineering programme. Throughout the book we have adopted a common format and approach with numerous student activities, examples, problems and key points.

About the BTEC National Certificate and Diploma

The BTEC National Certificate and National Diploma qualifications have long been accepted by industry as appropriate qualifications for those who are about to enter industry or who are receiving training at the early stages of employment in industry. At the same time, these qualifications have become increasingly acceptable as a means of gaining entry into higher education.

BTEC National programmes in Engineering attract a very large number of registrations per annum such that there is in excess of 35 000 students currently studying these qualifications in the UK by both part-time and full-time modes of study.

The BTEC National syllabus was recently reviewed and extensively updated and new programmes have been launched with effect from September 2002. The new scheme is likely to be adopted by *all* institutions that currently offer the programme as well as a number of others who will now be able to mix and match parts of the BTEC qualification with vocational GCSE and AVCE awards.

Many organizations have contributed to the design of the new BTEC National Engineering programme including the Qualifications and Curriculum Authority (QCA), the Engineering Council, and several National Training Organizations (NTO).

The Engineering Council continues to view the BTEC National Certificate/Diploma as a key qualification for the sector. They also recognize that BTEC National qualifications are frequently used as a means of entry to higher education courses, such as HNC/HND programmes and Foundation Degree courses.

In revising and updating the Engineering BTEC National programme, Edexcel has taken into consideration a number of issues, including:

- Occupational standards and NTO requirements.
- Professional requirements (particularly with regard to the engineering technician).
- Progression into employment.
- Progression to Higher National qualifications (with a particularly close match in the core units of engineering science and mathematics).
- A flexible course structure that is commensurate with the broad aims of Curriculum 2000.
- Relevant QCA criteria.
- External assessments (as required).
- Key skills signposting.
- Several other issues, including the ways in which the study of the area can contribute to an understanding of spiritual, moral, ethical, social and cultural issues.

To assist tutors and lecturers, the book is supported by an A4 format curriculum resource pack containing photocopiable resource material and information on assessment, grading and practical activities.

How to use this book

This book covers four of the core units that are common to BTEC National Engineering programmes. The remaining core unit (Project) is covered in the Curriculum Support Pack. Each unit contains Text, 'Key points', 'Test your knowledge' questions, Examples, Activities and Problems.

The 'Test your knowledge' questions are interspersed with the text throughout the book. These questions allow you to check your understanding of the preceding text. They also provide you with an opportunity to reflect on what you have learned and consolidate this in manageable chunks.

Most 'Test your knowledge' questions can be answered in only a few minutes and the necessary information, formulae, etc., can be gleaned from the surrounding text. Activities, on the other hand, make excellent vehicles for gathering the necessary evidence to demonstrate that you are competent in Key Skills. Consequently they normally require a significantly greater amount of time to complete. They may also require additional library or resource area research time coupled with access to computing and other information technology resources.

Many tutors will use 'Test your knowledge' questions as a means of reinforcing work done in class while Activities are more likely to be 'set work' for students to do outside the classroom. Whether or not this approach is taken, it's important to be aware that this student-centred work is designed to complement a programme of lectures and tutorials based on the BTEC syllabus. Independent learners (i.e. those not taking a formal course) will find complete syllabus coverage in the text.

In the units on Mathematics and Science, the worked examples not only show you how to solve simple problems but also help put

the subject matter into context with typical illustrative examples. In order to successfully tackle this work you will need to have a good scientific calculator (and get to know how to use it). In the units on Business Systems and Communications you will require access to a computer with word processing, spreadsheet, drawing and CAD software.

Finally, here are a some general points to help you with your studies:

- Allow regular time for reading – get into the habit of setting aside an hour, or two, at the weekend. Use this time to take a second look at the topics that you have covered during the week or that you may have not completely understood.
- Make notes and file these away neatly for future reference – lists of facts, definitions and formulae are particularly useful for revision!
- Look out for the inter-relationship between subjects and units – you will find many ideas and a number of themes that crop up in different places and in different units. These can often help to reinforce your understanding.
- Don't expect to find all subjects and topics within the course equally interesting. There may be parts that, for a whole variety of reasons, don't immediately fire your enthusiasm. There is nothing unusual in this; however, do remember that something that may not appear particularly useful now may become crucial at some point in the future!
- However difficult things seem to get – don't be tempted to give up! Engineering is not, in itself, a difficult subject, rather it is a subject that *demands* logical thinking and an approach in which each new concept builds upon those that have gone before.
- Finally, don't be afraid to put your new ideas into practice. Engineering is about *doing* – get out there and *do* it!

Good luck with your BTEC Engineering studies!

Mike Tooley and Lloyd Dingle

Unit 1 Business systems in engineering

This unit is designed to provide you with an introduction to the business and commercial aspects of engineering. It aims to broaden and deepen your understanding of business, industry and the effects of engineering on the environment. It also aims to provide you with a firm foundation for employment in the engineering industry together with an understanding of the financial, legal, social and environmental constraints within which an engineering company operates.
To achieve this unit you must show that you can:

- describe external factors that affect business and the economic environment in which engineering companies operate;
- describe the impact of relevant legislation, environmental and social constraints on typical engineering companies;
- explain and use basic project planning and control methods used in typical engineering companies;
- select and use costing techniques used in typical engineering companies.

This unit is assessed by portfolio assessment and you must include in your portfolio a full range of appropriate evidence. This can include assignment and case study work as well as reports, course notes and solutions to class-set problems. You should begin work on your portfolio as you start the unit and add to it systematically as you progress through the unit. You will also find it valuable to cross-reference the evidence in the portfolio to the individual learning outcomes and the list of evidence requirements. Your tutor will help you to do this.

This unit has strong links with the core units Communications for Technicians and Project. Wherever possible, you should apply the techniques that you have developed in the communications unit to work that you undertake in this unit. There are also links to several of the optional units including Quality Assurance and Control and Production Planning and Scheduling.

As you study this unit you will need to gain access to appropriate information and communications technology resources (including the Internet and the World Wide Web). You will also benefit from access to a well-stocked library of reference material. Your tutor will provide you with case study material featuring data on real or invented engineering companies involved with engineering production and manufacture, engineering services,

materials handling and transportation. He or she will also ensure that you have access to the relevant UK and EU Acts as well as relevant health and safety literature and other materials.

Case studies (based on real or invented engineering companies) are an important part of this unit. When you carry out a case study you will be presented with sample data to analyse. You might find it useful to relate your experience of employment or work experience periods in industry to the case study as well as to work covered elsewhere in the unit.

Introduction

All engineering companies must operate as commercial enterprises in order to survive. In this unit you will look at how external factors affect engineering companies and how engineering activities as a whole contribute to the economy. You will also learn about the importance of effective planning and control and about how and why companies make financial decisions. In addition, you will learn about environmental legislation and how it affects the engineering industry, and about how engineering companies design their operations to minimize adverse effects on the environment.

Some of the engineering sectors, engineered products and engineering companies with which you are probably familiar include:

Chemical engineering	Fertilizers, pharmaceuticals, plastics, petrol, etc. Companies in this field include Fisons, Glaxo, ICI and British Petroleum.
Mechanical engineering	Bearings, agricultural machinery, gas turbines, machine tools and the like from companies such as RHP, GKN and Rolls-Royce.
Electrical and electronic engineering	Electric generators and motors, consumer electronic equipment (radio, TV, audio and video), power cables, computers, etc., produced by companies such as GEC, BICC and ICL.
Civil engineering	Concrete bridges and flyovers, docks, factories, power stations, dams, etc., from companies such as Bovis, Wimpey and Balfour-Beatty.
Aerospace engineering	Passenger and military aircraft, satellites, space vehicles, missiles, etc., from companies such as British Aerospace, Westland and Rolls-Royce.
Telecommunications	Telephone and radio communication, data communications equipment, etc., from companies such as Nokia, GEC, Plessey and British Telecom.
Motor vehicle engineering	Cars, commercial vehicles (lorries and vans), motorcycles, tractors and specialized vehicles from companies such as Rover, Vauxhall UK and McLaren.

As you work through this unit it will help you to put things into context by relating the topics to those engineering companies with which you are familiar. This will give you an appreciation of the factors that affect their operation as well as the constraints under which they operate.

The production workflow and some of the functions in an engineering firm are shown in Figure 1.1. This production workflow starts with suppliers that provide an input to the various engineering processes. The output of the engineering processes is delivered to the customers. You may find this easier to recall by remembering the acronym *SIPOC*.

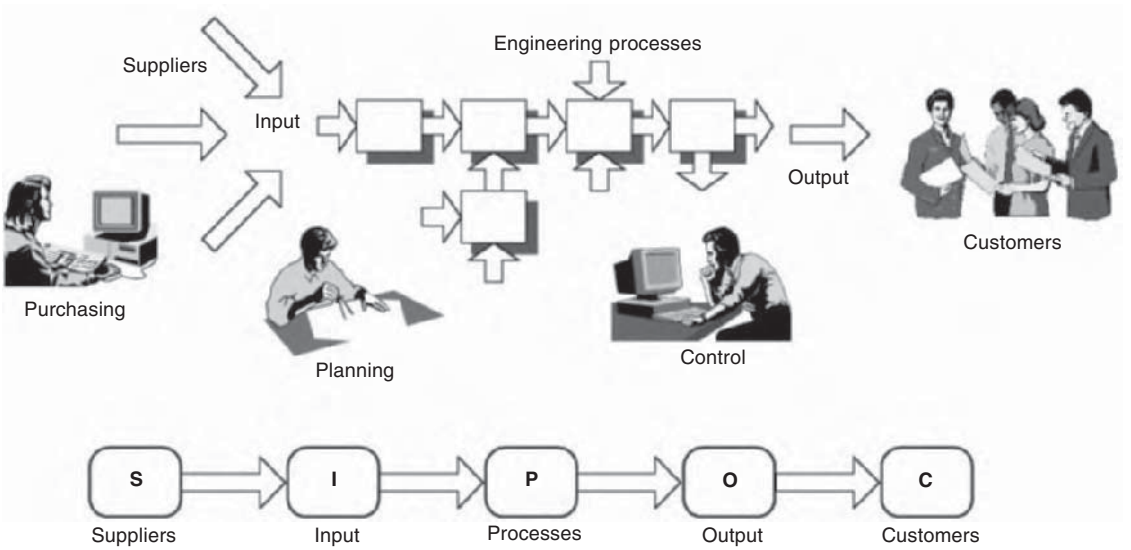


Figure 1.1 *Simplified view of the flow of work in an engineering company from its suppliers to its customers*

The three functions that we have included in the diagram (there are many more in a real engineering firm) operate as follows:

Purchasing	The purchasing function ensures that supplies are available as and when required by the engineering processes.
Planning	The planning function ensures that the correct engineering processes are in place and also that the workflow is logical and timely.
Control	The control function ensures the quality of the output and the cost effectiveness of the processes.

We will revisit these functions in some detail later in this unit but first we will look at the environment in which an engineering firm operates.

External factors and the economic environment

External factors affect the operation of all engineering companies. Some factors may be foreseen in which case they are predictable (and can be planned for) but others are seemingly random occurrences. Some external factors can be regarded as *threats* whilst others can be regarded as *opportunities*. For example, the availability of a new manufacturing process that significantly reduces costs can be considered to be an opportunity. Falling consumer demand

resulting from high interest rates can be considered a threat. Perhaps somewhat confusingly, some external factors can be considered to be either a threat or an opportunity depending upon whether or not a company is ready and able to respond!

External factors that you need to be aware of include:

- markets and the general state of the economy
- consumer demand
- demographic and social trends
- competitive products and services
- consumer confidence and customer/client relationships
- innovation and technological change.

Test your knowledge 1.1

Classify each of the following as a threat or an opportunity for a small engineering company:

- availability of low-cost business development loans
- interest rates climb to an all-time high
- high salaries offered by a major competitor
- a local college starting new courses in advanced manufacturing technology.

It's worth noting that, to some extent, all of these factors are present to a varying degree all of the time.

Figure 1.2 shows factors that affect a typical engineering firm. Some factors are considered to be internal (and part of the task environment) whilst others are external (and considered to be part of the wider environment). Internal factors are relatively easy to influence. External factors, on the other hand, may be difficult if not impossible to influence. Note that Figure 1.1 fits inside this diagram with the SIPOC stages fitting between 'Suppliers' and 'Customers' in the region that we have marked 'Core engineering processes'. Because it has far-reaching implications, it is important that you understand this diagram!

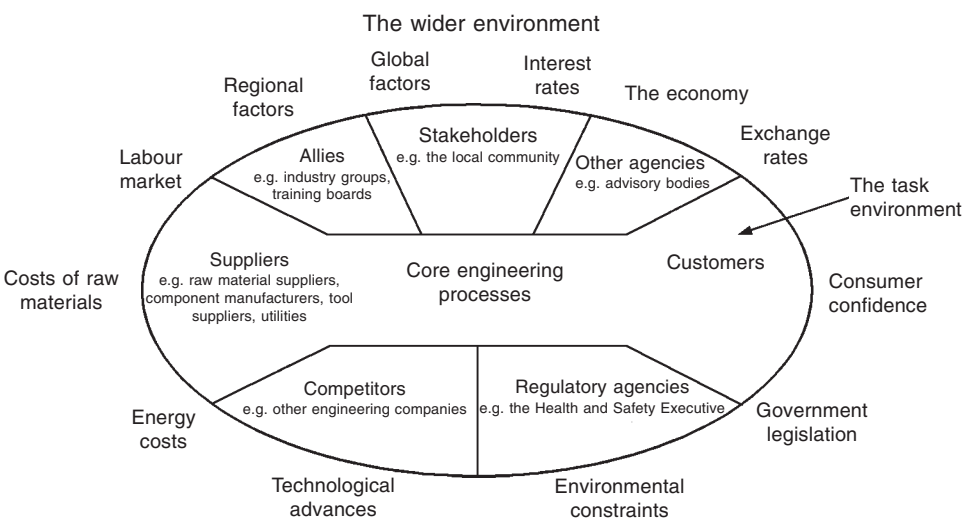


Figure 1.2 *Factors that affect a typical engineering firm. Note that the entire 'SIPOC' diagram (Figure 1.1) fits into the core of this diagram*

Activity 1.1

A small high-tech engineering company based in Kent manufactures a range of colour photocopiers. The company has a customer base in the south-east of England as well as northern France and Belgium. In common with other suppliers, the company offers a

Test your knowledge 1.2

A change of government may have consequences for the economy and in turn this may affect interest rates. Explain the likely consequences of (a) low and (b) high interest rates on the operation of a small engineering company.

standard warranty and an extended service contract of a six-hour 'fix or replace' response time when one of its copiers breaks down.

Assess each of the following scenarios on a scale of 1 to 5 (1 = negligible and 5 = major) on its likely impact on the operation of the company. In each case briefly explain your answer and suggest which of these scenarios represent a potential threat to the company and which can be regarded as an opportunity.

Present your work in the form of a brief word-processed report to the company's chairman.

(a) An earthquake in the Far East results in the destruction of a major semiconductor manufacturing plant.
(b) A major fire causing long-term suspension of all services through the Channel Tunnel.
(c) Funded by a substantial European Community grant, a French manufacturer sets up a colour photocopier production plant in Calais.
(d) A substantial fall in price of desktop colour laser printers.
(e) A Japanese company patents a new low-cost high-quality colour printing process.
(f) A series of strikes by workers in cross-channel ferry companies brings chaos to the channel ports.
(g) A progressive fall in interest rates results in an exceptionally large number of business start-ups in the south-east of England.
(h) A major high-street chain of newsagents decides to provide low-cost in-store colour photocopying.
(i) Well known for its high salaries and excellent benefits packages, a North American electronic equipment manufacturer sets up its European headquarters on the same industrial estate.
(j) New European environmental legislation makes manufacturers of electronic equipment responsible for its disposal and/or recycling.

Key point

External factors affect the operation of all engineering companies. Some of these factors can be predicted and planned for whilst others cannot. Some factors can be considered to be opportunities and some can be considered to be threats.

The economic environment

The economic environment is crucial in determining the financial context in which an engineering company operates. The profitability of an engineering company often goes hand-in-hand with the state of the economy as a whole but this is not always the case.

In order to understand the more important economic issues it is necessary to have a grasp of some basic concepts and terminology including gross national product (GNP), gross domestic product (GDP) and balance of payments.

Figure 1.3 shows how the production of goods and services and their consumption can be regarded as forming a closed circle. The firms make the goods and provide the services consumed by the people living in the households. The people living in the households are the same ones that own and work in the production and service

firms. The households create the demand for the goods and services. This, in turn, is satisfied by the production firms that pay the wages of the householders. Hence, the flow of goods and services and production resources is in one direction and this flow is balanced by the flow of money in the other direction.

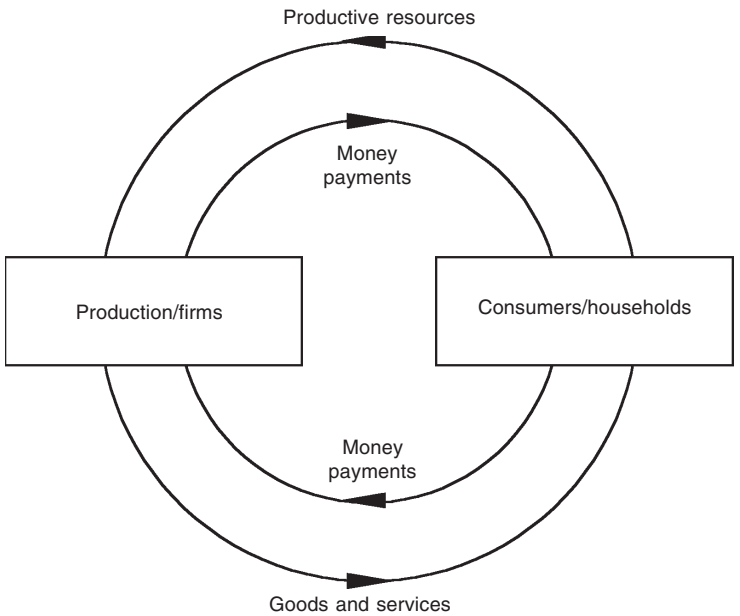


Figure 1.3 *Circular flow of goods, services, resources and money*

It's worth noting that many goods and materials used in engineering processes are not consumed for their own sake but are actually used in the production of other goods. They are known as *intermediate goods*. For example, sheet steel is used in the production of cars, wooden planks in the construction of buildings, copper wire in the manufacture of transformers, and so on. You may now be wondering how this all works in the knowledge that GDP only accounts for goods that are in their finished state. What about intermediate goods?

To explain this, consider the use of sheet steel in the production of cars (see Figure 1.4). Here, the output of the steel producer is sheet steel and this is regarded as intermediate goods in the car production process. The steel producer purchases iron ore (a raw material) from a mining company and uses it to produce sheet steel. This is then sold to the car manufacturer who produces the finished product. Only the final sale of cars is included in the calculation of GDP.

An alternative but equivalent way of measuring GDP is to add up the value added at each stage of the production process. The value added by the steel producer is the difference between the value of output (sheet steel) and input (iron ore). The value added by the car manufacturer is the difference between the value of output (finished cars) and input (sheet steel and other materials).

It is important to note that there will often be several stages in the process of intermediate goods production but the sum of value added at each stage of production must always be equal to the value of the final output.

Key point

The sum of the value added at each stage of an engineering production process is equal to the value of the final output. This gives us an alternative way of determining the GDP contribution of an engineered product.

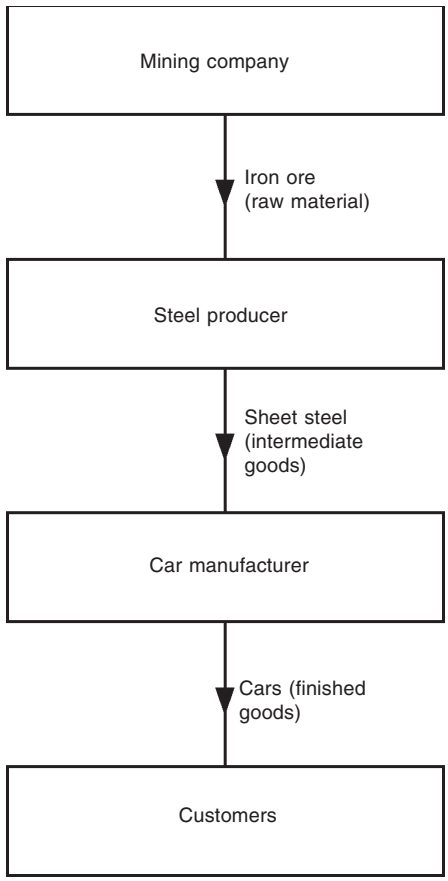


Figure 1.4 *Intermediate and finished goods in a car production process*

Gross national product (GNP)

The total output of the UK can be measured by adding together the value of all goods and services produced by the UK. This figure is called the gross national product. The word 'gross' implies that no deduction has been made for the loss in value of the country's capital equipment, which helps to make the national product, caused by normal wear and tear.

The word 'national' in this context does not mean that the GNP is the total output produced within the borders of the UK. The gross product of the UK includes some output taking place and produced by resources within the UK but owned by people from other countries. Therefore, this particular element of output cannot be regarded as part of our national income. At the same time, some sources of output are located in other countries but owned by UK citizens. Therefore the GNP is defined as the value of the total output of all resources owned by citizens of the UK wherever the resources themselves may be situated.

Gross domestic product (GDP)

If we measure the value of the total output produced within the borders of the UK, it is called the gross domestic product. So, the

GDP is defined as the value of the output of all resources situated within the UK wherever the owners of the resources happen to live. In many ways the GDP is a more important measure than the GNP.

The UK Government issues detailed statistics that indicate the performance of the different sectors of the economy. You can obtain more information from the National Statistics website (StatBase) at http://www.statistics.gov.uk

Gross national income (GNI)

Key point

The difference between GNP and GDP is that the latter includes income earned domestically by foreign nationals and excludes income earned by UK nationals in other countries. In other words, GNP is GDP plus net income earned overseas.

Gross national income (GNI) was traditionally called gross national product (GNP), even though it was a measure of income rather than output (or production). The term gross national product is no longer used within the official definition of economic accounts.

GNI is a measure of the income coming to the UK from production wherever in the world it occurs. For example, if a British-owned company operating in North America sends some of its profits back to the UK this *adds to* the UK's GNI. Similarly, a British subsidiary of a Japanese company sending profits to Japan will *reduce* the UK's GNI.

Strictly, gross national income is GDP *plus* the net income from the rest of the world, see Figure 1.5.

Gross domestic product (GDP)

less

Income payable to overseas divisions

plus

Income receivable from the rest of the world

equals

Gross national income (GNI)

Figure 1.5 *Relationship between gross domestic product (GDP) and gross national income (GNI)*

Key point

GDP per head is a measure of the productivity of a region or a nation. It relates output to the number of people employed producing that output.

Key point

Economists often use the terms 'output' and 'income' interchangeably. If this seems odd just remember that, for the economy as a whole, total production is equal to total income.

Activity 1.2

The UK's GDP for the 11-year period from 1989 to 1999 is shown in Table 1.1. Plot this data as a line graph. Also determine:

(a) the percentage increase in GDP over the ten year period from 1990 to 1999
(b) the average annual percentage increase in GDP over the ten year period from 1990 to 1999
(c) the year in which the actual increase in GDP was least
(d) the year in which the actual increase in GDP was greatest.

Present your results in a brief written report. Hint: You may find a spreadsheet useful for determining annual changes and also for plotting graphs.

Key point

The circular flow of income and expenditure leads us to conclude that there are two ways of measuring this flow – by adding up all of the income or by adding up all of the expenditure. According to the rules of accounting these two must be equal!

Table 1.1 *UK GDP (at current basic prices) for the 11 years from 1989 to 1999*

Year	GDP (£ million)
1989	461 925
1990	501 473
1991	523 137
1992	545 487
1993	573 377
1994	606 720
1995	635 498
1996	674 029
1997	715 127
1998	755 297
1999	787 385

Activity 1.3

Dragon Data Controls (DDC) is the UK subsidiary of a Japanese machine tool manufacturer. In one year, DDC receives a total income of £25 million from the sale of CNC equipment. Of this, £8 million worth of income comes from sales to other European countries. DDC returns £5 million of profit to its Japanese parent company. DDC imports £7 million of components from Japan and its UK costs (employment and overheads) amount to £13 million.

Explain the contribution that DDC makes to the UK's GNP and illustrate your answer using a pie chart. Present your work in the form of a brief word-processed report.

Gross domestic product per head

Gross domestic product per head is a measure of *productivity*. It relates output to the number of people employed producing that output. The formula used is:

output per head (or per capita) = output produced divided by the number of people producing it

Put another way, we can write:

output per head = output/employment

Often we are concerned not with absolute figures for output and employment but more with trends. For this reason, both the output and employment figures are usually quoted as *index* figures (i.e. they are stated relative to a base figure of 100 for a particular year). Table 1.2 shows how the UK output per head and cost of labour have changed over the eleven year period from 1990 to 2000.

Regional variations

There are significant variations in the economic performance of the various UK regions. Table 1.3 shows the GDP by UK region in

Table 1.2 *UK productivity and labour costs per unit for the period 1990 to 2000*

Year	Output (manufacturing jobs)	Output (whole economy)	Unit labour costs (whole economy)
1990	83.7	86.7	90.5
1991	86.2	88.4	96.8
1992	91.7	91.3	99.1
1993	96.2	94.5	99.5
1994	100.5	98.2	98.4
1995	100.0	100.0	100.0
1996	99.4	101.6	101.8
1997	100.3	103.1	104.8
1998	101.2	104.6	108.2
1999	105.2	105.8	112.3
2000	111.3	108.2	114.8

1996 and 1999. Given the different sizes and populations of the regions this table is not particularly meaningful in terms of the contribution of each person who lives and works in that region. To address this problem, Table 1.4 shows how the GDP varies on a 'per capita' (i.e. 'per head') basis.

Table 1.3 *Regional GDP in the UK for 1996 and 1999*

Region	GDP (£ million)	
	1996	1999
United Kingdom	674 029	787 386
North East	23 755	25 875
North West	68 937	77 562
Yorkshire and the Humber	50 043	57 554
East Midlands	44 184	50 906
West Midlands	54 851	63 495
East	66 484	81 793
London	99 490	122 816
South East	100 614	121 956
South West	50 128	58 151
England	558 483	660 108
Wales	27 017	30 689
Scotland	57 338	64 050
Northern Ireland	14 936	17 003

Activity 1.4

Present the data shown in Table 1.4 in the form of two bar charts in descending order of per capita GDP. Use the data to determine:

(a) the best and worst performing regions in each of the two years
(b) the region that has shown the greatest increase in per capita GDP over the four-year period