On the Importance of Manufacture to the Economy

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ABSTRACT

The future of manufacturing industries in this country and in the Western world more generally is frequently discussed in the financial press and elsewhere in terms which suggest it is not all that important. This paper analyses the real contribution which the research, design and production of manufactured products makes to Britain's economy and that of its competitors.

The paper also analyses the comparative contribution which the services sectors, including the financial services sector, make to the economy in productivity and balance of payment terms, and compares these with Switzerland's.

The paper introduces the economic engineering model (EEM) which connects market share and employment in a mechanistic quantitative way to management culture, marketing effort, Research and Design expenditure, capital investment and technological knowledge as embodied in production plant and IT systems. In particular, Britain and its principal competitor countries are compared on two key measures which have direct bearing on economic growth: the Export Effectiveness (EE), and Research and Design Effectiveness (RE) factors.

Finally the paper outlines what targets should be set to redress a situation in which British ownership and with it control over vital aspects of innovation is being relinquished in virtually every major manufacturing sector, even though manufacturing labour productivity is 60% higher than that of the services sector and contributes eight times the export sales per head[1].

[1] Most of the mathematical symbolism used is found in Sections 3 and 4. The key conclusions of these sections are embodied in Tables 5 and 6 and eq (3.12) (Section 3), and in Figs 5, 6, 7 and the last five paragraphs of Section 4.

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1. INTRODUCTION

Nine years ago, Ivan Yates, then recently retired as technical director of British Aerospace, delivered a paper[(Ref 1)] to the Manchester Statistical Society[2] in which he drew attention to the view prevalent in certain official circles that the growing trade deficit in manufactured goods didn't matter very much because it could be balanced by 'invisibles'. Mr Yates' paper was delivered against a background in which the British share of world manufacturing had steadily fallen, over 30 years, from about 14% in 1960 to 6% in 1990 (Fig.1). Of course, as newly industrialised countries in Asia entered the world's markets and Western European countries such as Germany and Italy recovered from wartime damage, it was likely that British manufacturers would lose market share to a degree. But in fact, the scale of the UK decline in market share (both of total manufacturing and of manufacturing exports) has been unique among major countries including the USA (whose share of exports declined from 18% to 12% over the period in question but has risen somewhat since)[(Refs 2, 3)].

While it is true that it was in the 1960's and 1970's when Britain lost most ground, the decline relative to our principal competitors continued through the 1980's albeit much more slowly. Thus while Britain's share of OECD manufacturing exports declined from around 9% in 1980 to 7% in 1990, West Germany's actually increased from 16.7 to 18%, while her manufacturing sector also expanded[(Ref 4)] showing that there is nothing inexorable about the decline in manufacturing in modern economies despite claims to the contrary by many influential commentators[3].

In the USA for example, the Annual Report to the President on the Trades Agreement Programme 1984-85[(Ref 5)] commented (p.43) that "The progression of an economy such as America's from agriculture to manufacturing to services is a natural change." Forbes magazine[(Ref 6)] proposed that "Instead of ringing in the decline of our economic power, a services driven economy signals the most advanced stage of economic development. Instead of following the Pied Piper of re-industrialisation the US should be concentrating its efforts on strengthening its services". Business World[(Ref 7)] suggested that "strong modern economies do not seem to require a dominant manufacturing sector."

Similar comments are current on this side of the Atlantic, particularly in the financial pages of the broadsheet newspapers. "Four million people making things contribute about the same to the national economic cake as a quarter of a million people in the City"[(Ref 8)] is perhaps an extreme expression of this view but as factories in Britain close down one after the other, received opinion in much of the British financial press is that, regrettable as individual job losses always are, it doesn't matter overall because services will automatically expand to fill the void left by manufacturing. In this view the other main industrial economies exhibit much the same trend: Britain and America are merely leading the way into the new service-based First World economy in which most manufacturing will be subcontracted to the newly industrialised countries (NICs) and the Third World. This view ignores, of course, the fact that manufactures are still by far the largest element of world trade (about 70%) and constitute much the largest fraction of Britain's own exports (about 75%) which are required both to pay for imports and to sustain economic growth (Section 3).

[2] 19th February 1991

[3] In the 1990's manufacturing output in the Republic of Ireland has more than doubled for instance.

Later in this paper, we shall examine quantitatively the makeup of the remaining 25% of our exports, ie that attributed to the services sector, but for the moment it is worth examining exactly how our principal competitors – the other leading industrial countries - arrange their affairs.

1.1 The position of our principal competitors

We will refer mainly to the USA, Germany, Japan, Italy and Switzerland. It is instructive to consider which country in this group (and the Organisation for Economic Development (OECD) countries generally) has the highest manufacturing output per head of population, per employed person, and which country has the highest Gross Domestic Product (GDP) per head.

As may be seen from Table 1 the answer, surprising to some, is Switzerland in each case[Ref 9].

Country	**Manufacturing output per head of population $**	**Manufacturing output/person employed in manufacture $**	**GDP per employed person $**	**GDP per head of population $** (1.54$ = £1)
Britain	3,400	49,900	36,200	16,100
USA	4,100	60,900	51,100	23,100
Italy	5,300	61,000	48,000	20,600
Germany	6,800	67,000	45,000	21,700
Switzerland	9,400	77,400	72,200	36,200

Table 1: Comparisons of Manufacturing Output and GDP per head (1994)[Refs 9, 10]

Those who have visited Switzerland may wonder where all the industry is. It is certainly there of course, but Switzerland shows that high levels of industrialisation are perfectly compatible with care for some of the most stupendous scenery and beautiful views in the whole world.

Also shown in Table 1 are the average labour productivity figures for each economy (GDP figures per employed person) in 1994, the main reference year for this paper. It is noteworthy that Britain's labour productivity in manufacture, at 49,900$/employed person, or about two-thirds of the Swiss figure, is 36% higher than the average for the economy as a whole.

UK manufacturing productivity was in 1994 some 57% higher than that for the services sector (31,700$/employed person – Table 6 in Section 3 beow) and the difference has been maintained since. In contrast, the Swiss data[(Ref 10)] shows their average services labour productivity to be almost that of the manufacturing sector which makes their services productivity, at about 70,000$/employed person - over twice that of Britain's. These figures should dispose of the oft repeated view that viewed internationally, Britain is in some way 'good at services'[(Ref 11)], compared with our allegedly laggard performance in manufacture. (Sections 5 and 6 below discuss the components of the Services sector and compare Britain with Switzerland.)

Country	**Period**	**Real GDP per person at beginning of period $**	**Real GDP per person at end of period $** (GDP is measured in 1965 dollars)	**Growth Rate per year %**
Japan	1890-1900	842	16,144	3.00
Canada	1870-1990	1,330	17,070	2.15
West Germany	1870-1990	1,223	14,288	2.07
United States	1870-1990	2,244	18,258	1.76
United Kingdom	1870-1990	2,693	13,589	1.36

Table 2: Real GDP Growth 1870-1990

Table 2 shows the average growth of five major economies between 1870 and 1990. The figures show that Britain's economy grew much more slowly than the other four. Overall from 1870 to 1990 Britain, with an average annual growth rate of 1.36%, moved from first position to tenth among the 16 countries[(Ref 12)]. A number of different factors have operated at different times during that 120 years to produce this relative decline. However, the enduring reason has been the inability to compete on value (as defined in eq 3.6 below) over the broad range of traded services and manufactures[4] (as modelled in Fig 1 for the last 30 years of this period). This reason both causes and is aggravated by a disproportionate number of people in non-traded services – what may be termed the overhead element of the economy.

[4] There are some outstanding exceptions to this generalisation

1.2 The Question of Economic Statistics – GDP and GNP

Conventionally, Gross National Product (GNP) per head of population is taken as a measure of standard of living enjoyed by the residents of a country while Gross Domestic Product (GDP) is taken as a measure of the output of the economy. For most economies GDP and GNP are not greatly different. While clearly a difference between say Britain at about $20,000 in 1998 and India at about $600 indicates a real difference in living standards, when we look at the smaller differences between the countries in Table 1, e.g. Switzerland at $36,200 and Britain at $16,000, we may ask if there really is a factor of two difference in living standards and if so, why?

There is in fact a whole literature on the British relative decline since 1870 (e.g. Refs 13-17) but with GDP per head of population increasingly used as a measure of economic competence, the differences in Table 1 also highlight the question as to what GDP represents. There are conventionally three ways in which GDP is calculated (Section 3): one calculates what is paid out by firms to produce the outputs, i.e. the costs of providing the outputs; another by what the government and consumer spend on goods and services and what industry spends on investment; the third, by the incomes derived from employment, profits and rents.

For tradable goods it is relatively easy to obtain output figures. We know the prices at which goods are sold i.e. the **outputs** and because in Britain every company has to prepare accounts, we know the cost of all the inputs – labour, capital, materials, components and services. Also because most goods are easily transportable, the prices they fetch are subject to often intense competition from abroad. In a real sense then most goods are provided at their minimum delivered cost. It is a basic view of this paper that the conventional 'output' GDP computation is better regarded as the 'cost of output' rather than output itself. If it costs more to lease a building in the UK than in the USA, or to eat a meal in a restaurant, then these are comparative disadvantages, not advantages for people in Britain.

1.3 The role of services in the GDP computations

There is no generally accepted definition of what constitutes services[Refs 18, 19], but for the purposes of this paper, a service will be defined as a sequence of actions performed by a human being at a particular time and place for which they or their employer is paid. Thus services cannot be stored (though instructions can be), and while some services by one individual can be emulated more or less by another (by using the same sequence of instructions), services do not have the huge replicating power of modern manufacture or computation, nor can they be physically or chemically analysed in the way tangible products can be. Services may use manufactured items as part of their procedures and these manufactured goods (e.g. computers in insurance companies; microwaves in fast food outlets) will usually be the principal source of any increased productivity observed.

On the above definition, services may be divided into three classes:

(1) Those services which are performed as a part of the process of producing and distributing tangible products [tangibles dependent services TDS].

(2) Those services which are bought by consumers directly or are inputs to such services [Direct Service Outputs DSO]

(3) Government – provided services paid for by consumers and firms through taxation, or inputs to such services. [GPS]

Now if a Category (1) service, such as a financial or legal service, is more expensive in Britain than in a competitor country, then this represents a loss of competivity in the British production sector in the same way that a higher cost of raw materials or energy would be. Yet in the computations of GDP, this higher service cost appears as a higher 'output' of the service sector.

Likewise in Category (2) the consumer does not see the fact that if they pay £15 for a meal which in France costs say £10 it shows as a 50% increase in the UK service sector 'output', nor do they see the fact that domestic insurances are often cheaper in Britain than elsewhere as constituting a smaller 'output' from this sector.

The same considerations apply in Category (3): if national postal services are generally cheaper in Britain than elsewhere, this is a competitive advantage, not a disadvantage. However as a consequence of the accounting procedures, British postal and insurance services will have a lower relative 'output' in GDP terms than some competitor countries. While services in one country cannot be exactly compared with those in another, once GDP is seen as the cost of output, rather than output itself, gross differences in the costs of services supplied to production and the consumer, not only in respect of the private services costs but also, for example, in the burgeoning regulatory costs of the public sector, will cause such services to be seen for what they really are, namely overheads. Well-run businesses of course need to minimise, not maximise, their overheads.

1.4 Comparative Costs of Manufactures and Services

Figure 2 shows the decrease in the cost of the transistor – the basic unit of digital computing and information technology generally - over the last 30 years. The graph shows a price reduction of a factor of *nearly a million times* in 30 years, obtained essentially from the million-fold increase in the number of transistors per integrated circuit and the huge replicating power of modern production.

Over 30-40 years, all manufactured products show either a large real price reduction, though not as dramatic as this (e.g. polyethylene about 15 times) - or big changes in the benefits provided at basically the same price (e.g. cars).

With the services sector in Britain accounting for almost 70% of costs of output, the question naturally arises as to that sector's productivity record. Now manufacturing decreases real costs as the rate of output is increased through the application, principally, of technology and capital equipment. Solow[(Ref 20)] for instance attributed about 60% of productivity gains over a 40 year period to technology with the remaining 40% split equally between capital and labour. Competition in manufacturing tends to force product specialisation; the control over complexity (as in the integrated circuit) which technology gives, provides enormous opportunity for

product variety. This in turn allows specialisation to occur, thus completing the virtuous circle.

For many services on the other hand, dependent on human effort as they are, wage costs per unit of output tend to go up, not down, through the use of percentages to fix fees in the private services sector or by appeals to wage comparability as in the public services sector. As shown in Sections 5 and 6 below, the overall effect of this in the British economy is to render large parts of the service sector an expensive overhead on productive industry while, on average, at the same time, those services offered directly to the public, when judged internationally, have, as we have seen, rather low productivity.

The cash flows between these different sectors and sub-sectors of the economy are set out in the next section using a cell model of the economy.

2 CELL MODEL OF THE ECONOMY

In order to see what is contributed by each part of the economy - manufacturing, financial services, distribution, and so on - a structure of nesting cells has been adopted as illustrated in Fig 3. The mathematical structure of relevant parts of the model is described briefly in Sections 3 and 4, and Appendix A, and more fully elsewhere[Ref 21]. As far as possible the cells correspond to sectors or subsectors used in the International 1980 Standard Industrial Classification (ISIC) used to compile national statistics over much of the period under review.

Figure 4 represents the simplest cell structure of a national economy which allows us to model its behaviour in terms of growth of Gross Domestic Product (GDP), employment, manufacturing, services, exports and imports. The data shown on the figure is for 1994. In considering international trade and competivity the largest units will be the national economies themselves as shown in Fig 3. Within the national economy are the usual macro economic sectors (denoted by a single digit) which themselves consist of individual sectors (denoted by two digit numbers). These sectors are given in Table 3, together with the percentage of GDP associated with each sector for 1994.

Within the sectors are found individual subsectors or industries (Fig 3) denoted by three digits. Thus the chemical industry is the third subsector of the manufacturing sector (12) and is denoted 123. Within a subsector or industry there will be specific businesses making specific products, for example, polyester within chemicals. Specific businesses or products are generally denoted by a superscript. Here we should note that some commercial businesses, e.g. conglomerates, will appear in more than one subsector or even macro sector. Appendix A explains how this numbering logic is used to set up the cell model.

It is a principle of the cell model that each sector or subsector or firm is seen as a business to and from which flow materials, goods, cash and services, the first three of which may be accumulated within a cell. It is for this fundamental reason the cell model is referred to as the Economic Engineering Model (EEM) by analogy with the successful cell models constructed on the same principle in Chemical Engineering[Ref 22]. This concept is in tune with the common feature of all but the smallest of modern businesses, namely to subdivide them into a series of cost centres. Moreover, data is fairly readily available in this macro-economy of interest rates and exchange rates. It allows us to see what would happen to GDP and the

Balance of Payments if a particular sector or subsector or firm were subtracted from, reduced or expanded for instance.

Macro Sector		**Sectors**				
		Number	**Name**	**ISIC[5] 1992 1980**	**£ bn 1994**	**%**
1	Private Industry	10	Primary Industry[6]	A, B	11	1.8
		11	Extraction	C	15	2.5
		12	Manufacturing	D	128	21.2
		13	Utilities	E	16	2.6
		14	Construction	F	31	1.3
		1	Subtotal: Industry	A → F	201	33.3
2	Private Services	20	Distribution	G	67	11.1
		21	Tourism & Travel[7]	H	21	3.5
		22	Transport & Telecoms	I	51	8.4
		23	Financial Services	65-67	42	7.0
		24	Technical Services	73, 74	21	3.5
		25	General Business Services	70-72	65	10.8
		26	Sewerage & Waste Disposal	90	9	1.5
		27	Other Services	91-93	16	2.6
		2	Subtotal: Private Services	G → K	292	48.3
3	Public Services	30	Defence	(	23	
		31	Public Administration	(L(75)	16	
		32	Education	M (80)	30	
		33	Health & Social Work	N (81)	42	
		3	Subtotal: Public Services	L → N	111	18.4
Total cost of output (GDP)					604	100.0

Table 3: Cost of Macro Sectors 1-3 at basic 1994 prices[8]

Within the private services macro sector (Table 3), eight service sectors are distinguished. Of these eight there are three: financial services (sector 23), technical services (sector 24), and general business services (sector 25) where the proportion bought by the consumer directly is relatively small compared with that bought as an overhead on the activities in the industry macro sector. Later in the paper (Section 5) we discuss the service economy as a whole but viewing financial, technical and business services as overheads is consistent with seeing the sectors and subsectors of the economy as businesses having both direct and overhead costs. Note that 23-25 *together* constitute finance and general business services in the Pink Book(Ref 23).

[5] ISIC 1992 – letters, SIC 1980 (revised) numbers
[6] Primary industry, i.e. Agriculture, Fisheries, Forestry
[7] Includes personal and business travel
[8] Source TSO 1999, and calculation this paper

Financial, technical and business services are not the only overheads however. Public services (macro sector 3 in Table 3) are paid for by the tax streams (not shown in Fig 4). These streams may also be seen, at least in part, as overheads on other sectors (however beneficial or necessary some of their services are judged to be).

2.1 Cash Flows in the 1994 UK Economy

Fig. 4 shows aggregate cash flows arising from the provision of goods and services by the 1994 economy. Not shown are current account flows arising either as dividends (inflows) from past UK investments abroad or dividends (outflows) from past foreign investment in Britain. These are discussed in Section 6. Also not shown are new investment flows into and out of Britain (i.e. capital account flows) which are a separate matter.

National statistics generally present cash flows in and out of the national economy in two classes "visibles" and "invisibles". With this approach all the imports of goods (or tangibles) are debited to the industrial macro sector (specifically manufacturing sector 12) while all the imports of services are debited to the private services macro sector.

Viewing these macro sectors as export businesses, however, it is necessary to debit whatever imports are necessary to carry on their business, whether goods or services. This is what the cell model does. It enables one to see what each sector contributes to the balance of payments. This will be shown in the next section to be crucial to the overall growth of the economy.

Figure 4 shows that while industry alone produces goods for export, each of the other two macro sectors are major importers of goods, to enable them to carry on their business. The financial and general business service sectors (23 and 25) are the largest importers of Information Technology (IT) equipment for instance. Likewise both these sectors are major importers of building components. If we had no domestic IT or construction industries at all, these imported products would still have to be paid for.

Allowing for these flows drastically changes the perception of industry's and services' relative contribution to the balance of payments. A net export credit of £7 billion to service sectors 21-27 becomes a net debit of £14 billion once imports of equipment, goods and materials are taken into account. By the same token, the actual difference between the exports of raw materials, machinery, and semi-finished manufactures to make them at £78 billion is £57 billion. As can be seen in Fig 4, it is this surplus which allows the other parts of the economy to function. This includes the importation of consumer goods (£40 billion), which end up in the private consumption sector (41) in Fig 4.

Private expenditure is one of the ways in which the output from the three macro sectors 1-3 is accounted for, and at £393 billion or 65% is much the largest. Table 4 gives the main categories of private expenditure. As can be seen individual consumers spend about 76% of their income on the products of industry (chiefly goods) and 24% on services. These figures mirror quite closely the proportions of goods and services in international trade.

	Source of Output	% total Private Expenditure	Expenditure £bn
1	Industry, of which:		
	Food & Drink	24	93
	Vehicles & Fuel	11	44
	Household Fittings & Appliances	12	47
	Clothing, Leisure & Personal Goods	15	58
	Housing	12	47
	Heating & Lighting	2	8
	Total Industry	76	297
2	Private Services, of which:		
	Leisure & Tourism	11	44
	Household	5	19
	Transport (Fares)	2	8
	Personal	2	8
	Car Maintenance	2	7
	Other	2	8
	Total Private Services	24	94
3	Public Services	<1	2
	Total 1 + 2 + 3	100	393

Table 4: Distribution of Private Expenditure[9] (Sector 41) by Source of Output 1994[10]

Now Ricardo's principle of Comparative Advantage (1822) is often called in aid to support the idea that under a completely free trade regime it is to be expected that one country will be strong in one field while being relatively weak in or indeed absent from others. For small economies there may be some truth in this, but for the G7 economies and several smaller ones this is contradicted by the facts as Scott(Ref 24) has pointed out. The main components of trade between these countries are, in fact, the products of the same subsectors of the manufacturing sector (cell12). An economy which wishes to grow in step with its competitors' thus has no option but to keep broadly in step with the product preferences of its own consumers (Table 4) which as we have seen reflect these of the international customers quite closely.

The next section examines how the way in which Britain deploys its economic resources affects its growth rate over the medium to long term.

3 EFFECT OF EXPORTS AND IMPORTS ON GDP

Referring to the cash flow diagram of the economy (Fig 4), we find that a simplified estimate of gross domestic product (GDP or G) may be expressed by any of the three methods used by the statistical authorities (Ref. 25, Ch. 15 and Tables 15.1 to 15.3) as follows (ignoring stock

[9] Excludes public services paid through taxation
[10] Annual Abstract of Statistics 1999 (Ref 25)

changes). The nomenclature is set out in Appendix A Section 2. F_{14} for instance, means the cash flow from cell 1 to cell 4. Index zero means "abroad". Then,

(1) Output Basis:-

By cash flow balance on cells 1, 2, 3 (sectors 10-14, 20-27, 30-32) taken together

$$G = (F_{41} + F_{42} + F_{43}) + (F_{01} + F_{02} + F_{03}) - (F_{10} - F_{20} - F_{30}) \quad (3.1)$$

Sales to home market — Exports — Imports

(2) Expenditure Basis cell 4 (sectors 40 to 42)

$$G = F_4 - F_{04} \quad (3.2)$$

Expenditure on goods and services — Net foreign credit and asset sales

(3) Income Basis cell 4

$$G = F_{14} + F_{24} + F_{34} \quad (3.3)$$

Income from Industry (cell 1) — Income from Private Services (cell 2) — Income from Public Services (cell 3)

Table 5 (below) gives the values of consumption for each of the sectors 40-42 in cell 4, and further breakdown of the investment sector 40 into its principal subsectors 401-404.

Figure 4 displays the added values in the three output macro sectors and the corresponding cash flows in and out of the UK economy. These flows are generated by the numbers of people shown in Table 6. Clearly the disproportion between the export productivity of the industry macro sector at £23,700 per head and that of private services macro sector (£3,030 per head) is even greater than for output productivity on its own (added value per employee).

In addition to equations (3.1 to 3.3) we need to obtain industrial production (X_1) and the Balance of Trade (B) by cell balances. Industrial production added value X_1 is given by a balance on cell1:

$$X_1 = (F_{41} + F_{01}) - (F_{10} + F_{12}) - F_{13} \quad (3.4)$$

Sales Purchases Taxes

Sector		£ billion	% GDP
40	Investment of which: 401 Industry 402 Private Services 403 Public Services 404 Housing	106 25 34 29 18	17.5 4.1 5.5 4.5 3.0
41	Private Consumption	393	65.1
42	Public Expenditure	109	18.0
	(Imports – Exports)	(4)	(0.6)
	Total GDP	604	100

Table 5: Macro sector 4: Consumption (Disposal of GDP) 1994

(5) Balance of Trade (B) is given by (balance around cells (1-3) taken together:

$$B = (F_{01} + F_{02} + F_{03}) - (F_{10} - F_{20} - F_{13}) \qquad (3.5)$$

Exports Imports

The analysis which follows assumes that over a 5 - 10 year period B will be small compared with either Exports or Imports - although there is nothing automatic about this.

Macro Sector	Numbers Employed[11] millions	% of total employ-ment	Added value £ bn	Added value per employee £	Exports[12] £ bn	Exports per employee £	Labour productivity relative to economy average
1 Industry	5.7	22.6	201	35,300	135	23,700	1.50
2 Private Services	14.2	55.2	292	20,600	43	3,030	0.87
3 Public Services	5.8	22.7	111	19,100	-1	-	0.81
Totals (average) 1 + 2 + 3	25.7	100.0	604	(23,500)	179	(7,050)	(1.00)

Table 6: Distribution of Employees, GDP and Exports 1994

3.1 Effect of Product Value and Marketing on GDP

By product value V_i we mean for a product originating in cell *i*

$$V_i \equiv \frac{\text{Benefit of product to customer } (B_i)}{\text{Price of product to customer } (\rho_i)} \tag{3.6}$$

Value V_i given in eq. 3.6 is in fact a precise expression of competivity and leads directly to market share, when market coverage is comparable with that of competitors.

Benefit may be expressed in the form of cash, either as saving (as in a component which reduces the cost of the customer operating a process or business), or as something which allows the customer to charge a higher price for a final product, or as a cheaper alternative to an existing comparable product or service of known cost.

The concept of market coverage expresses the fact that any product will not in general be exposed to all potential customers. This is particularly so in export markets where marketing will often have to concentrate on a few countries for reasons of cost. However, there is another factor besides marketing which affects market coverage.

If we are comparing the sales of a given micro cell or industry, say chemicals and pharmaceuticals, the share of the export market achieved by that industry will depend not only on V_i but also on the range of individual product types and species which it makes. If a country specialises too much within a particular sector it will limit its share of the corresponding export market and indeed home market. There is clear

[11] Includes self-employed
[12] Pink Book 1999 (Ref 23)

evidence (see below 4.1) that Britain's growth is being restricted in this way, i.e. by simply not making a large enough variety of things to sell.

The combined effect of marketing and product range may be expressed by the market coverage factor (f_{ij}) (for a product made in cell (i) sold in market (j). If electric motors are made available in the full range from 0.5 to 100 kW, f_{ij} will in general be close to unity for the home market but probably smaller for foreign markets.

The combined effect of product value (V_{ij}) and market exposure (f_{ij}) determines the share S_{ij} of market (j) obtained by product (*i*) according to:

$$S_{ij} = \frac{f_{ij}\ V_{ij}}{\sum_{i}^{I} f_{ij}\ V_{ij}} \qquad (3.7)$$

In equation (3.7) a subscript *i* zero will refer to all overseas suppliers competing in the home market (*j*). A subscript j zero means all overseas markets which may be supplied by cell *i*. For the simplified national economy shown in Fig 4, j has the value 4 (expenditure cell) and the source of industrial products (*i*) has the value 1 or zero. The V_{ij} of one country may be as high as the V_{ij} of competitor countries in the denominator of eq (3.7). But if its f_{ij} is low than so will be its market share S_{ij}.

We may regard the export market E_o as consisting of all other countries having an aggregate GDP of G_o and average import penetration p_o, so that:

$$E_o = p_o\, G_o \qquad (3.8)$$

Then income from exports from the UK is (Fig 4)

$$F_{01} + F_{02} + F_{03} = S_{10}\, E_o \qquad (3.9)$$

UK share of world export market

Expenditure on imports into the UK is

$$F_{10} + F_{20} + F_{30} = S_{04}\ F_4 \qquad (3.10)$$

Intermediate goods and raw materials

Capital goods

Transfers and capital goods

Overseas share of UK market (or total demand F_4)

From (3.2) and (3.5) equations (3.9) and (3.10) give the balance of trade B as:

$$B = S_{10}\ E_o - S_{04}\, F_4 = S_{10}\, E_0 - S_{o4}\,(G\text{-}B)$$

Hence

$$S_{10}E_0 - S_{04}G = B\{1 - So_4) \tag{3.11}$$

If over the long term the average value of B is small compared with the import share of GDP ($S_{04}G$) then equation 3.11 gives:

(3.12)

$$G \approx \left[\frac{S_{10}}{S_{04}}\right] E_o$$

very closely[13]. Thus GDP is directly proportional to the world export market, which is not under our control (or any one country's) and the market share ratio (S10/S04) which as we have seen [eq (3.7)] is dependent on the product of value and market coverage.

Value equation (3.6) is the ratio of benefit to price. As discussed in Section 4, benefit is fundamentally dependent on product design and innovation. Price is dependent on the production process.

4 MARKET SHARES, TECHNOLOGY AND MARKETING

It is clear from equation (3.12) that UK GDP depends over the long term on the share of world exports achieved by the UK products divided by the share of the UK market obtained by imports. Both shares depend on the value of British products relative to those of their overseas competitors. Quantifying the factors which determine value, as defined by equation (3.6), is a major goal of the Economic Engineering Model (EEM). The calculated graph of UK share of World manufacturing shown in Figure 1 is an output from a recent version of the EEM.

A good deal of data has been collected at various times (e.g. Refs 1-3, 9, 13-17, 26-30) to compare export performance by country and by industry for Britain and her major industries in particular. The Economic Engineering Model connects the value $V_{ij}^{(k)}$ of a product (k) from country (i) in market (j), with various efficiencies and effectiveness factors for converting money spent on research, design and development into actual products. This process is set out diagrammatically in Figure 5.

But even good products will not sell if they are not marketed[14]. The market share $S_{ij}^{(k)}$ is thus a compound function of market exposure $f_{ij}^{(k)}$ and product value $V_{ij}^{(k)}$ (eq 3.7).

[13] A balance of trade deficit will be balanced in cash terms (eq 3.2) by a combination of foreign credit, attracted by relatively high interest rates, and of asset sales often misrepresented as "inward investment". Both of these mechanisms have been strongly exhibited by Britain and the USA in the 1990's.

[14] E.g. the US generally has a market share smaller than would be expected by V_{ij} because, apart from such hi-tech items as arms, computers and aircraft, it has not hitherto marketed its products very widely.

$V_{ij}^{(k)}$ is defined by equation (3.6) above as the benefit to price ratio of product K, made in country i and sold in country j. Using a heavy degree of simplification to bring out the main features of $V_{ij}^{(k)}$, gives[Ref 21].

$$V_{ij}^{(k)} = K_{ij}^{(1)} \left[Q_i / Q_{io} \right]^{bi} \Delta K_i^{di} \qquad (4.1)$$

where embodied new knowledge is given by

$$\Delta K_i^{(k)} = k_i^{(2)} U_i^{(k)} \qquad (4.2)$$

and

$Q_i^{(k)}$ is scale of production of product (k) in country (i)

$Q_{io}^{(k)}$ is average scale for comparison countries

$U_i^{(k)}$ is cash spent on R & D for product (k) by country (i)

As shown diagrammatically in Figure 5:

$k_{ij}^{(1)}$ is the Embodied Knowledge Factor (EKF)

$k_i^{(2)}$ is the R & D Effectiveness Factor (REF)

Actual market share is achieved as described in Section 3 (eq 3.7) is proportional to

$f_{ij}^{(k)} V_{ij}^{(k)}$

where $f_{ij}^{(k)}$ is the proportion of the market $F_j^{(k)}$ in country (j) exposed to product (k). Where the market is restricted by national prejudices or political decision (e.g. cars and defence equipment) the real market size $F_j^{(k)}$ available to foreign competition is reduced below the apparent size.

4.1 Estimating factors $k_{ij}^{(1)}$ and $k_i^{(2)}$ for various countries

Distinguishing between the effect of market coverage and product value is not easy but it is important if realistic assessments are to be made of the scope for improvement in any country's performance.

Figure 6 gives the ratio (e_i) of export sales (ES_{io}) of country (i) in a given year to averaged annual industrial R & D expenditure (U_i) in the five preceding years, at decade intervals in the period 1970–2000 for a number of countries (i). E is the relevant world export market, in this case all manufactured goods.

This ratio (ei) is proportional (eqs 4.1, 3.7) to the product

$$e_i \equiv f_{io}\, ki^{(1)} ki^{(2)} \left(Q_i / Q_i \right)^{b_i} / \sum_j^n f_{jo} V_{jo} \qquad (4.3)$$

where the summation covers all competing countries. (e_i) may be termed the overall export effectiveness factor (EEF). The bracketed term represents the effect of scale of production Q_i relative to that of the average of all competing countries Q_{10}. The $k_{ij}^{(1)}$ and $k_i^{(2)}$ correspond to each of the two main stages in converting R & D cash into value (Fig 5[15]). As may be seen, in 1976 there was a very large variation between countries from below 10 for the USA to greater than 60 for Italy.

The low value for the USA (i = 2) shown in Fig 6 is essentially because of its low value of marketing exposure f_{20} in the export market. The difference between Britain and Germany in 1976 has virtually disappeared by 1986 and the two countries remain close together in 1996. Italy continues to get by far the best value for its R & D money, though the difference with other countries is markedly reduced by 1996.

A readily identifiable measure of embodied knowledge used by other workers (e.g. Ref N) is the number of patents (N_i) filed in the US patent office by other countries. These data can be obtained for each major industrial sector. We can write for all industries in country (i)

$$N_i = k_i^{(3)} \Delta k_i \tag{4.4}$$

or

$$g_i = \left(N_i / U_i \right) = k_i^{(3)} k_i^{(2)} \tag{4.5}$$

is the average number of US patents filed per unit of cash U_i spent by country (i) on R & D. $k^{(3)}$ is the fraction of knowledge included in the patents N_i.

It should be noted that g_i is a very incomplete measure of knowledge generation: many firms prefer not to patent their designs, relying instead on keeping commercially sensitive knowhow to themselves(Refs 26-30).

Figure 7 plots g_i, the number N_i of US patents filed by other countries over the same period, per unit of R & D (U_i) spent annually in the preceding five years(Ref 31). Pavitt (Ref. N, p.43) gives US patents granted from 1890 to 1975 for six countries mostly included in Fig 7. Conversion of applications into actual grants typically runs between 65 and 90%.

Figure 7 shows that the patent generation factor $g_i = k_i^{(2)} k_i^{(3)}$ is (a) remarkably similar for Britain and Germany over the whole period 1976-1996, and (b) all the European countries plotted converge over the period from very disparate values of g_i in 1976.

Looking at Figures 6 and 7 together we see that both the two key effectiveness factors e_i and g_i have been much the same for Britain and Germany for around 15 years, though both are significantly different from Italy, Japan and the USA (for different reasons). The general decrease in g_i for all countries except Japan will be mainly due

[15] The data used for U_i in Figure 6 is from Ref 4 and has been collected for Research and Development. Similar countries may be taken as having proportionate design expenditure, most of which will be capitalized in I (Fig 5).

to the increased costs of patenting. The recent rise in g_i for Japan is probably due to a deliberate policy of increased patenting, i.e. an increase in $k_i^{(3)}$.

It may be reasonably concluded from these figures that in determining export shares (S_{io}) the chief difference now between Germany and Britain is principally the size (Q_i) not the efficiency of their manufacturing industries (eq 4.1).

Table 6 (above) shows how in 1994, Britain's human resources were distributed between the three output generating macro sectors of the economy (Fig 4). As can be seen, industry labour productivity was some 72% greater than private services labour productivity and 85% greater than public services labour productivity[16]. Moreover, as can be deduced also from Table 6, the exports per person employed in industry are around 8 times those in private services and 140 times those in public services.

It is crystal clear from all these figures that a transfer of resources into industry (especially manufacture) at the expense of private and public services would have a markedly beneficial effect on:

(a) export market share S_{io} (through increase in Q_i) eq (4.1)

(b) on overall growth (through S_{io} – eq 3.12)

(c) average labour productivity (Table 6).

In fact, Bacon and Eltis' 1976 thesis of too few (quality) producers still applies(Ref 17); the only difference in the 1990's is that it is the low productivity private services sector which is the main problem rather than low productivity public sector, which though still low in productivity has contracted in numbers to about one third of the private services sector. The contraction of the public sector is more apparent than real however, since many government and Quango functions have been contracted out to nominally private sector firms who rely on government contracts to perform the same functions.

Sections 5 and 6 examine why the common perception of the character of the private services sector is so different from the actual facts as summarised in Table 6.

5 THE PRIVATE SERVICES SECTOR

While it is often remarked that the future lies with the service economy (e.g. Refs 5-8, 11) it is not always clear what is meant by this. Frequently there is an elision of meaning in the financial press**:** services are equated with financial services which are equated with the City of London. In foreign trade, the phrase 'invisibles' is used as opposed to 'visibles' or goods. Often the income from overseas investments is quoted as an 'invisible' earning and credited to financial services. As noted in section 6 below, investment income is not mainly due to financial services at all – the single biggest item being due to the overseas investment earnings of the UK oil industry. Moreover, we will show that the true net overseas earnings from financial services are smaller than normally assumed, and only about the same

[16] It is acknowledged that some part of the disparity in productivity will be due to the high proportion of part time employees in some service sectors.

magnitude as those from technical services which are themselves dependent on industrial products.

5.1 Cash Flows in the Services Sector

The principal sectors in the private services macro sector are shown in Table 3, Section 2 above. Table 6 in Section 3 records the notional added values (or cost of output) per head, exports, and employee numbers for the three macro sectors in the economy.

Both the private and public services macro sectors are heavily dependent on tangible products, i.e. on the output of the home and overseas industrial sectors. Conventionally in national economic statistics, all tangible imports from the overseas industrial sector (whether going to any of the 3 macro sectors) are automatically debited to the home industrial sector when constructing the trade balances for each sector(Ref 23). This has the effect of making the industrial sector look as if it were a net burden on the balance of payments showing (1998) a deficit of around £20 billion p.a.

By the same token the services sector's contribution to the balance of trade (eq 3.5) is exaggerated. The financial services sector(Ref 23) in particular is the major importer of IT equipment in the whole economy – computers and telecoms - and is a major importer of building fittings[17].

As noted in Section 2 it is the standpoint of this paper to treat each sector and subsector of the economy as a business, adding value or incurring costs, providing employment, selling exports and buying imports. Equation (3.12) shows that the effect on GDP of the contraction or expansion of any given tradable product or service is twofold**:** loss or gain in the export market (E_o) and increase or reduction in import penetration of the home market.

Figure 4 shows an estimate of the import and export flows to each of the three output macro sectors of the 1994 British Economy. As may be seen, the industrial macro sector in total exported about £135 billion and imported about £78 billion to enable it to do it. Most of the exports were from manufactured goods, as were about £60 billion of the imports. The remaining imports went mainly to machinery, raw materials and utilities.

The private services macro sector (accounting for about 48% of the cost of GDP) was responsible for about £42 billion exports and about 56 billion of imports. Distribution, (included within private services, but separately identified as sector 20 in Fig 4) costing about 10% of GDP output, imported £40 billion – mainly consumer goods, but also computers, trucks and shop fittings. The public sector services sector was responsible for an estimated £7 billion of imports. Clearly if the distribution cell in particular were able to reduce its dependence on imports, by its very size this would have a substantial effect on GDP (eq 3.12). Likewise if the cost of the financial and business services provided to the production sector were reduced by just 5%, it would

[17] The 800 ft Canary Wharf tower in London's Dockland was estimated to have cost the balance of payments around £1.5 billion in imports for instance.

reduce the cost of the traded goods by this amount, making them that much more competitive (eq 3.6).

5.2 Observations from Tables 3 and 6

First, average labour productivity in the private services sector at £20,600 p.a. is on average not much more than about half that in the industrial sector (£35,300) or rather less than two-thirds that in manufacturing at £32,400 (Table 1)[18]. Labour productivity in the public services sector at £19,000 is basically the same as in the private services sector, reflecting similar skill levels and comparable salaries.

As will be seen in Section 6 and contrary to much supposition, the contribution to exports of financial services (including insurance) while important, is at £6.4 billion (sector 23) smaller than that for royalties and technical services (24) at £8.2 billion. As a technical service, engineering consultancy alone generated £1.7 billion net export credits(Ref 23). All these figures are small compared with manufacturing exports at £135 billion (Fig 4) and net (export minus imports) exports of £57 billion.

Moreover very large numbers of people in the services sectors are needed to generate their exports – 1.6 million in tourism and travel, around 3 million in finance and general business services which generate very few exports. Only technical services – themselves dependent on the industrial sector – match the exports per head in manufacturing of around £34,000 gross or £14,000 net of imports.

The reason why these figures will come as a surprise to some is because the actual export earnings of the financial sector are often conflated with the income from overseas investments(Refs 8, 11) which is the major contributor to the invisibles flows. These are set out in the next section.

6 THE INVISIBLE FLOWS AND BALANCES

Together with Visibles (i.e. tangibles), Invisibles make up the current account. As can be seen from Table 7, investment income accounts for two thirds of the invisible flows in 1994, and it continues to do so(Ref 25).

It is important to see however that these investment income flows are attributable to the whole economy: they do not originate only with the financial services sector. Thus we see that direct investment by non-financial companies (e.g. developing an oil-field in Alaska) gave the largest single positive balance in 1994. Portfolio investment (e.g. managed funds, unit trusts, private equity portfolios) had a significant net credit in 1994 of £5.4 billion which decreased steadily to £684 million by 1998. The other major financial source of investment income, described as 'other' in the Pink Book(Ref 23), namely banks deposits, loans and other financial instruments was actually strongly negative throughout the 90s being minus £10.6 billion in 1994 and minus £4.7 billion in 1998. Bank deposits are hardly investments at all since many are simply back to back loans in which a loan in one country is matched by a deposit in another – thus generating positive and negative each flows which should more or

[18] Industry productivity is higher than manufacturing on average because of the very high capital to labour ratios in oil extraction and utilities.

less balance out. Nonetheless these flows are conventionally added to the flows from real investments to give the credits and debits shown at A3 in Table 7.

				Credits	Debits	Balances
A	**Investment Income**		**Source**	**£bn**	**£bn**	**£bn**
	of which	A1	Private non-financial corporations (e.g. investment in plant)[19]	20.7	11.0	9.7
		A2	Portfolio investment by financial sector	21.9	16.5	5.4
		A3	Bank deposits, loans, other finance	40.7	48.1	-7.4
Total Investment Income Flows				83.3	75.6	7.7
B	**Private Services**					
	of which	21	Tourism, travel	10.9	14.7	-3.9
		22	Transport, telecom	10.5	10.6	-0.1
		231	Insurance	2.1	0.5	1.6
		232	Financial	4.3	0.2	4.1
		24	Technical	8.1	3.7	4.4
		25	General Business	5.6	4.9	0.7
Total Private Services				41.5	34.6	6.9
C	**Public Services**	30-33		1.3	2.1	-0.8
D	**Government transfers[20]**			3.3	8.4	-5.1
Total Invisibles Flows (A + B + C + D)				129.4	120.7	8.7

Table 7: The Invisibles – Flows and Balances 1994

In fact, the increase in net overseas investment income between 1994 and 1998 of £7.4 billion shown in the 1999 Pink Book(Ref 23), Table 4.1, was almost all accounted for by an increase in non-financial direct investment income of £6.6 billion which has nothing to do with the financial services sector or the service sector as a whole for that matter. The increase was due to the expansion of overseas investment by 'tangibles' companies spread throughout the industry macro sector.

[19] Source: Pink Book 1999 (Ref 23).
[20] Mainly to European Union institutions

6.1 Returns on (a) direct, (b) portfolio investments

This sharp increase in direct overseas investment by industrial companies raising their foreign assets (from £190 billion to £283 billion in the period 1994-98) naturally raises the question of rate of return on this direct investment and, for comparison, on portfolio investment which is in the hands of the financial sector (232). These are shown Table 8.

		1994		1998	
		Assets[21] £bn	**ROI** %	**Assets** £bn	**ROI** %
(a)	Direct overseas Investment by Industrial Companies	190	12.5	283	11.5
(b)	Portfolio investment by financial cell	410	5.3	720	3.8

Table 8: Returns on UK Overseas Investment (ROI)

To be successful and pay an acceptable return, direct investment takes real management input – adaptation of products to market, assessment of competition, continued downward pressure on costs, recruitment of suitable labour with the requisite skills, personnel adaptation to foreign conditions and so on. The returns obtained by the investing company will be aimed to be comparable with those obtained on their UK operations and are usually paid for by retained earnings.

Portfolio investment on the other hand depends heavily on hints in the financial newspapers, second-guessing company results, follow-my-leader strategies in making stock purchases and sales and so on. Sometimes there may be some 'research' by 'analysts' but by comparison with direct investment, the effort deployed is only a tiny proportion of the sums involved – and at risk. The results show up in the much lower yields obtained for portfolio investment compared with direct non-financial investment (Table 8). The drop from 1994 to 1998 largely reflects the fall in world interest rates and consequent upward valuation of equities and bonds between those dates. The fall in returns on direct investment is proportionately very much smaller.

6.2 Services and Investment Earnings: UK and Switzerland Compared

Given the frequency of remarks about the efficiency of the British services sector and the financial sector in particular(Ref 8), it is instructive to make comparison with Switzerland, a country noted for banks, tourism, dependable transport system as well as manufacturing.

Table 9 gives the Swiss data for our reference year 1994. Swiss francs are translated to £s at the then exchange rate of 1.90.

[21] Assets data in Refs 3, 25; incomes shown in Table I (Ref 23)

	Credits £ bn	Debits £bn	Balance £bn
(a) Investment Income	18.9	7.9	11.0
(b) Services	16.3	8.4	7.9
(c) Transfers	2.6	8.8	-6.2
Total Invisibles	37.8	25.1	12.07

Table 9: Swiss Invisibles balances 1994, Source Ref 32

Comparing the Swiss figures in Table 9 with the British figures in Table 7, and recalling that the Swiss working population is about 11% of the UK's, out of which it provides the world's largest per capita manufacturing output (Table 1), it is clear that the productivity of the UK financial services sector seen internationally is not particularly impressive to say the least. In two categories of invisibles: investment income and services, the Swiss balance is actually greater in absolute terms than the UK's and about 14 times on a per capita basis. Only in transfers is the Swiss balance worse than the UK's, (mainly due to remittances abroad by foreign workers) but easily offset by the other two categories to give an overall balance 50% greater than the UK's with about 11% of its population. While the Swiss authorities clearly value the contribution which the financial sector makes to their economy, there is nothing like the special attention given to the City of London by successive British governments so clearly analysed by Cain and Hopkins recently[(Ref 33)]. The Swiss authorities have, however, through interest rate policy been successful in holding the Swiss franc within a range of 80-85 cents to the Deutschemark over the 20 years to 1999, in order to maintain international manufacturing competivity.

7 CONCLUSIONS

1 Over the medium term, Britain's economic growth rate is governed mainly by the world market growth rate multiplied by the ratio of the UK export share of world markets to the import share of the British market. Over the 40 years to 1990, France's superior growth rate is broadly attributable to a lower import share, Germany's superior growth rate to a higher export share than Britain's.

2 Since manufacturing accounts for about 76% (1994 figures) of British exports – as it does broadly for the other three major economies in Europe – there is a strong correlation between manufacturing output per employed person in the economy and overall growth of the economy.

3 Switzerland has the highest GDP and the highest manufacturing output per person of any industrial economy in the world. Germany, Japan, France and the USA sit in between Britain and Switzerland on both these measures.

4 Taking the conventional measure of labour productivity as added value per employee, Britain's manufacturing labour productivity at £32,000 p.a. (1994) is about 60% greater than the productivity in the private services sector (£20,000 p.a.) and about 68% greater than that in the public services sector (£19,000 p.a.).

5 Foreign earnings per employee in manufacture are around eight times those of employees in the private services sectors.

6 The economic engineering model (EEM) of an economy (regional, national, world) is based on the flow-cell principle. This treats each sector and subsector of the economy as a business to which all the costs incurred in producing its added value are attributed. This has, inter alia, two consequences for the way the macro-economy is viewed:

(i) The private services sector is now debited with the imports of manufactures – principally vehicles, IT and building construction goods – which it incurs to carry on its business. Likewise, manufacturing is debited with any imported services which it uses. On this basis, the manufacturing sector (in 1994) earned £135 billion in exports and incurred around £78 billion imports of raw materials, components and machinery, a net contribution to the balance of payments of £57 billion or £14,000 per employee. No other sector comes near that positive contribution and most are negative.

(ii) Many services to business – legal, accountancy, regulatory – can now be seen as overheads on the output of marketed goods and services. There is evidence that by comparison with competitor countries – Japan, Switzerland, Germany – Britain is overburdened with such overheads. Reducing them by 20% would translate into a 2.3% reduction in export price, providing in turn an increase in world market share.

7 The conventional Gross Domestic Product (GDP) calculation of an economy is thus better seen as the cost of GDP. This paradigm shift is of particular significance for an economy like Britain's where (c.f. Conclusion 1) both exports and imports play a large part in the economy. If we as a country are in the export business, then everything possible should be done to reduce costs, including the legal and accounting costs of takeovers and demergers. These currently are counted as "outputs" in the GDP calculation, but in reality are overheads on the costs of the merged or demerged busnesses.

8 Besides the visible earnings from manufacturing, there are three principal so-called invisible cash flows on current account which are often conflated, but which in reality have very different origins. The three invisible flows are those arising from:

(i) Private services, including credits and debits arising from tourism, telecoms, technical consultancy as well as financial and insurance services.

(ii) Overseas investment credits and foreign investment debits

(iii) Government transfers.

9 An analysis of the private services sector which accounts for around 44% of the cost of outputs shows that (1994 figures) its output per employed individual (ie labour productivity) is around one half that of the industrial sector (or about 60% of the manufacturing sector), a disparity which has grown through the 1980's and 1990's.

10 While the private services sector accounts for about 60% of employees, it accounts for about £42 billion or 23% of total export credits. Its reported balance of trade £4.8 billion (1994) becomes negative when its imports of capital goods, such as IT equipment and office building fittings (customarily debited to the manufacturing sector!) are allowed for (around £8 billion). This contrasts with £135 billion or 76%

of total export credits, £57 billion net of imports, generated by the manufacturing sector with around 18% of total employed persons[22].

11 Investment income credits are currently about double those of the private services sector (which includes financial services) or £83 billion in 1994. However, investment income debits are 85-90% of credits (£75.6 billion in 1994), again about double those of the private services sector, giving a net contribution to the balance of payments of about £7.7 billion in 1994.

12 Investment income credits and debits may themselves be divided into three principal sources(Ref 23) which represent very different rates of return: (a) private non-financial direct investment, (b) financial services portfolio investment and (c) 'other' investment – chiefly bank deposits and loans. Non-financial direct investment refers to transactions between companies that are organisationally related and situated in different countries. These direct investments have nothing to do with the financial services sector, but arise directly from the industrial sector, a typical example being investment to develop an oil field in a foreign jurisdiction. In recent years, these flows (a) have accounted for about 25% of total investment income and practically all of its net contribution to the balance of payments (Conclusion 11). The return on these investments, totalling £190 billion (1994) and £283 billion (1998), fell slightly during the 90's from 12.3 to 11.5%.

13 The income returns on portfolio investment (b), i.e. funds managed by the financial services sector – unit trusts and investment trusts – are much smaller – around 4.5% (on investments valued at £480 billion) in 1994 falling to 3.8% in 1998. The factor of three difference between its returns generated by (a) direct and (b) portfolio investment reflects the very large difference in expertise at the disposal of the two sectors.

14 'Other' investments (c), mainly bank deposits often in the form of back to back loans, showed credits (£41 billion) comparable with the two investment streams put together, but showed debits of £48 billion reflecting their large negative burden on the balance of payments throughout the 1990's.

15 The economic engineering model allows us to compare national economies (i) and individual industries (j) on two measures which have direct bearing on their shares (S_{io}) of the world export markets. EEF - the Export Effectiveness factor – is the ratio of annual Export Sales to annual Industrial Research and Design expenditure (U_i). PGF – the ratio of US patents generated to annual industrial research and design expenditure may e taken as a surrogate for Research Effectiveness Factor (REF)(Ref 28). Taken together, the two ratios REF and EEF express the efficiency with which expenditure on new knowledge is generated and embodied in marketed goods.

16 From the mid-1970's to the mid-80's the UK's Export Effectiveness Factor (EEF) was the lowest of the four major European economies, but from then until the present (1998) it has been close to Germany's, though both are significantly below Italy's by about 25%. From the mid 1970's to the present the UK's industrial Research and

[22] The public services have about 22% of employed people account for about 18% of the cost of output. They make a contribution of about £1 billion to export credits mainly through universities' education of foreign students.

Design Effectiveness factor (RE) has been close to those of Germany and Switzerland.

17 Only Research & Design spending financed by, or directly linked to, industry appears to have significant benefit for exports. Britain's industrially-financed R&D as a proportion (45%) of total UK R&D is the lowest among the main European economies and may be compared with 68% for Switzerland. (In addition, Swiss-owned companies spent more than this amount outside Switzerland).

18 A high proportion of industrial R&D need not be bought at the expense of fundamental scientific contributions: from 1975 to 1996 Switzerland won 6 Nobel prizes for science – the highest per capita ratio in the world in this period.

19 Using known industrial R&D expenditure data and including the effects of scale of production, the Economic Engineering Model represents the fall of UK share of world manufacturing exports from 1960 to present day pretty well, albeit somewhat exaggerating the effects of change from year to year. This is because the effects of R&D are felt over a longer period than the five years currently allowed for in the model. On the basis of the model, if UK manufacturing capacity were 10% larger than it is, with the same embodied knowledge (EK) and Research and Design Effectiveness (RE) factors, and the additional output split exactly between exports and the home market, then the rate of GDP growth for the whole economy would increase by around 20%.

20 The overall conclusion of this paper is that the manufacturing sector of the UK economy is far and away the principal vehicle for converting knowledge into export value; it is currently too small to enable Britain's real economy to grow as fast as our competitors'; it bears an unnecessary burden of high regulatory, financial and legal services costs; its labour productivity is 60% greater than the private services sectors'; it is (among our principal competitors) averagely efficient in converting cash into useful knowledge and knowledge into product value, and on these two key measures has shown marked improvement from the mid 1980's onwards. A diversion of annual R&D expenditure of around £2.5 billion from the public sector on to industrial products and processes, provided and only provided, these were embodied in additional plant costing about £10 billion, would increase GDP growth by around 20% (see Conclusion 11 above). By contrast, the private services sector is markedly less productive than the best of our competitors' and offers no realistic alternative to maintaining an efficient manufacturing sector, ideally about 25% greater than its present size.

APPENDIX A

Cell Structure and Nomenclature of Cash and Goods flows in the Economic Engineering Model (EEM)[Ref 21)]

As far as possible, the cell structure reflects production and services categories for which data is provided by the national statistical offices of the main industrial countries. Considerable progress has in fact been made of late in agreeing common category definitions through the international standard industrial classification (ISIC) system 1992. The numbers and categories used in the EEM are those currently applied in the United Kingdom Statistical Office publications – principally the Annual Abstract of Statistics[(Ref 25)] and the UK Balance of Payments – The Pink Book[(Ref 23)].

1. Cell Structure

Structure is defined in Figure 3. Microeconomic cells or subsectors (3 digit numbers, e.g. Tables 5 and 10) correspond to broad classes of goods recognisable by the public, such as electro-mechanical goods.

Subsectors nest within economic sectors (Tables 3 and 8 - 2 digit numbers) which correspond to established categories recognised by economists and economic statisticians. These cells in turn nest within four macro cells (Table 3.1 digit number), which correspond to the broadest categories of national economies – industry, private services, public services and consumption.

Generally, the subsectors will be made up of individual businesses which will make types of product e.g. electric motors, mobile phones – and so on. Clearly there are some conglomerates which span several subsectors and even the macro sectors, but most such conglomerates are themselves in the form of wholly-owned subsidiary companies operating in a closely coupled group of markets i.e. in one subsector in our terms.

Because the basis of this structure is the individual firm, each with its own total sales, export sales, import purchases, and added value per head, it is possible to express each subsector and sector as businesses in the same way. This is the standpoint of this paper. It enables one to see the effect on long term GDP if a firm is removed from the economy or a whole cell is reduced in size. As remarked in Section 1, this viewpoint differs fundamentally from the way economic statistics are usually presented e.g. in the National Statistical Office Publications[(Refs 23 and 25)] where the flow of goods and services in and out of the national economic boundary (Fig 4) is referred to as ‘trade’ as if the economy were one large emporium divorced from the business of production.

Table 3 in Section 2 sets out the principal denumeration used in this paper together with its relationship to the ISIC codes used in Ref 23 and 25.

Cell		Microcell		£ bn
No.	**Name**	**No.**	**Name**	**Output/Exp**
12	Manufacturing (all tradable)	122	Chemicals and pharmaceuticals	45
		123	Electro Mechanical (incl. vehicles and aerospace)	42
		124	Food, Drink, Plastics, Paper	47
41	Private Expenditure {	411	Food and drink	93
	Tradable {	412	Vehicle & fuel	43
	{	413	Household fittings	47
	tangibles {	414	Clothing, leisure, personal goods	58
	{	415	Housing	47
	Non-tradable {	416	Car Maintenance	8
	{	417	Heating and light	7
	{	418	Other nes.	4
Total Tangibles				307

Table 10: EEM – Cells and Microcells

2. Flow from one cell to another

Within a national economy cash and goods flows from cell *i* to cell *j* are denoted F_{ij}, G_i, respectively. Where there is no ambiguity (i.e. for flows between macrocells when i, j, are ≤ 9) the comma betweem the i and the j is omitted. When individual product types (k) are concerned, then flows are denoted $F_{ij}^{(k)}$, $G_{ij}^{(k)}$.

Between material economics, the same nomenclature applies. When we are comparing the exports of one country (*i*) with another for a particular product type or subsector or sector we employ the notation $F_{io}^{(k)}$ where the suffix zero means all countries other than country (*i*), and k can be whichever of product type, industrial subsector, or sector is being compared in the various national economies.

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NOTATION

B Balance of trade (eq 3.5)

B_1 Benefit of Product originating in (cell) (i)

b_1 Scale of production factor (eq 4.3) in country (i)

d_1 Knowledge generation scale factor (eq 4.1)

E_o Size of export market for country under consideration

e_i Export effectiveness (EE) factor – Annual Export sales by country (i) per unit R&D expenditure

F_{ij} Cash Flow from cell (sector) (i) to cell (sector) (j)

G Gross domestic product (eq 3.1)

G_o Aggregate GDP of countries providing the Export Market E_o

g_j Patent generation factor number of US patents generated (filed) per unit of cash U_i spent on R&D by country (i) (surrogate for Research Effectiveness (RE) factor

ΔKi New knowledge embodied in products of country (i)

$k_{ij}^{(1)}$ Embodied Knowledge (EK) Factor for products (i) delivered to market (j)

$k_i^{(2)}$ Research & Design (R&D) Effectiveness (RE) factor for country (i)

$k_i^{(3)}$ Number of US patents generated (filed) per unit of new knowledge Δk_i

N_i Number of patents filed in the US patent office per annum by country (i)

P_{ij} Price of product made in sector (i) and sold in market (j)

P_o Average import penetration for countries providing export market E_o for each country being considered

$Q_i^{(k)}$ Scale of production of product (k) in country (i)

$Q_{io}^{(k)}$ Average scale of production for comparison countries

S_{ij} Share of market (j) obtained by product (i)

$U_i^{(k)}$ Cash spent on Research & Design (R&D) for product (k) in country (i)

V_{ij} Value of product made in cell (sector) (i) to customer in market (j) (eq 3.6)

X_i Industrial Production added value in sector (i) (eq 3.4)

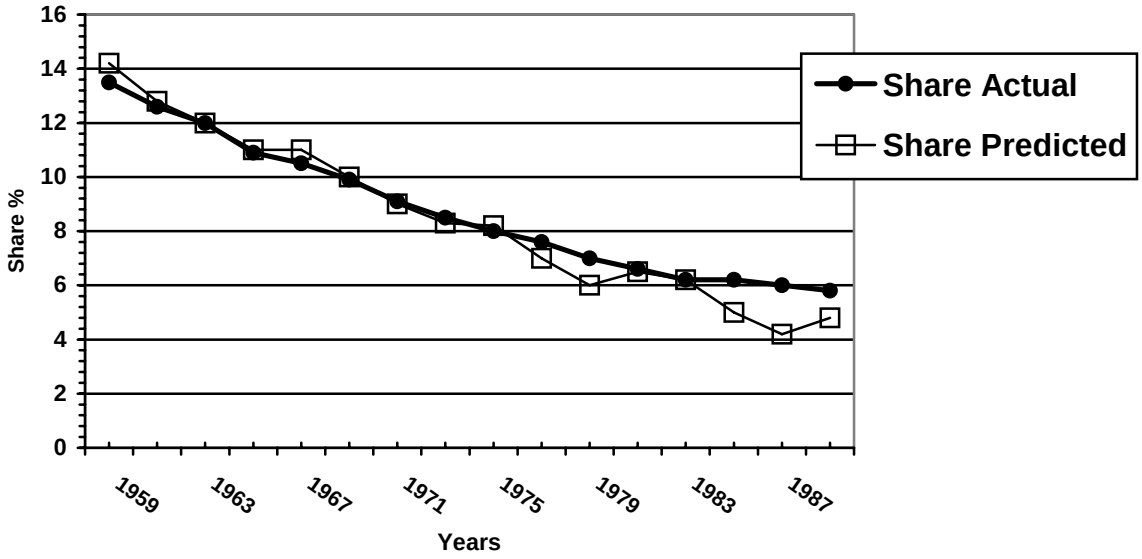


Figure 1: UK Shares of World Manufacturing 1959-1988: (a) Actual, (b) Predicted
Source: (a) OECD Main Economic Indicators 1959-1989, (b) Economic Engineering Model (Ref 21)

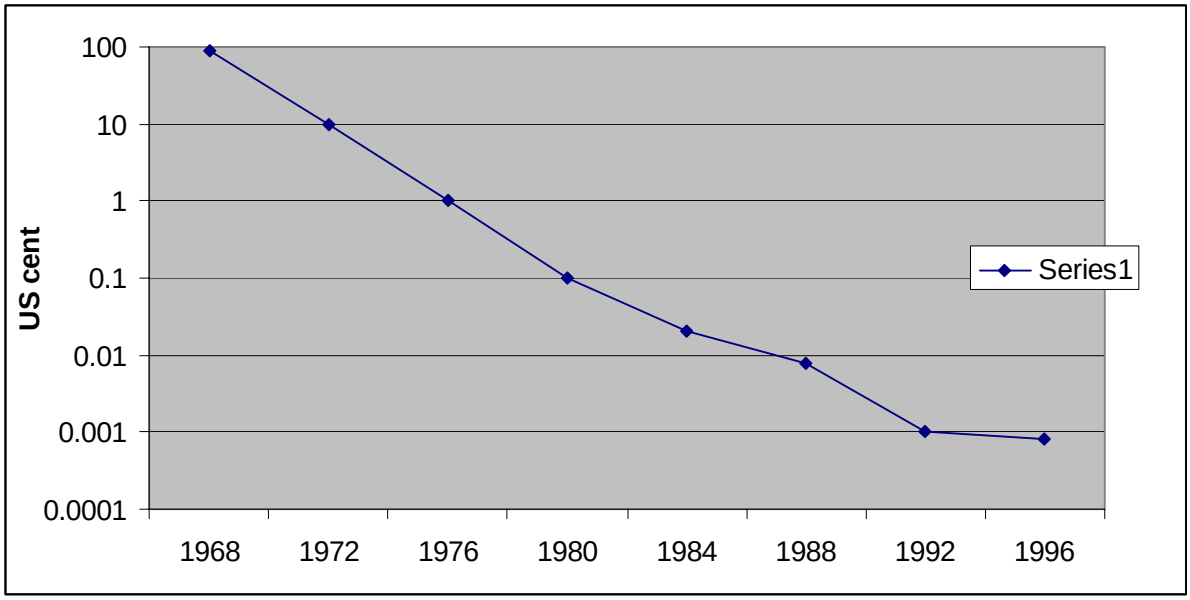


Figure 2: Average transistor Price in U.S. Cents 1969-1996

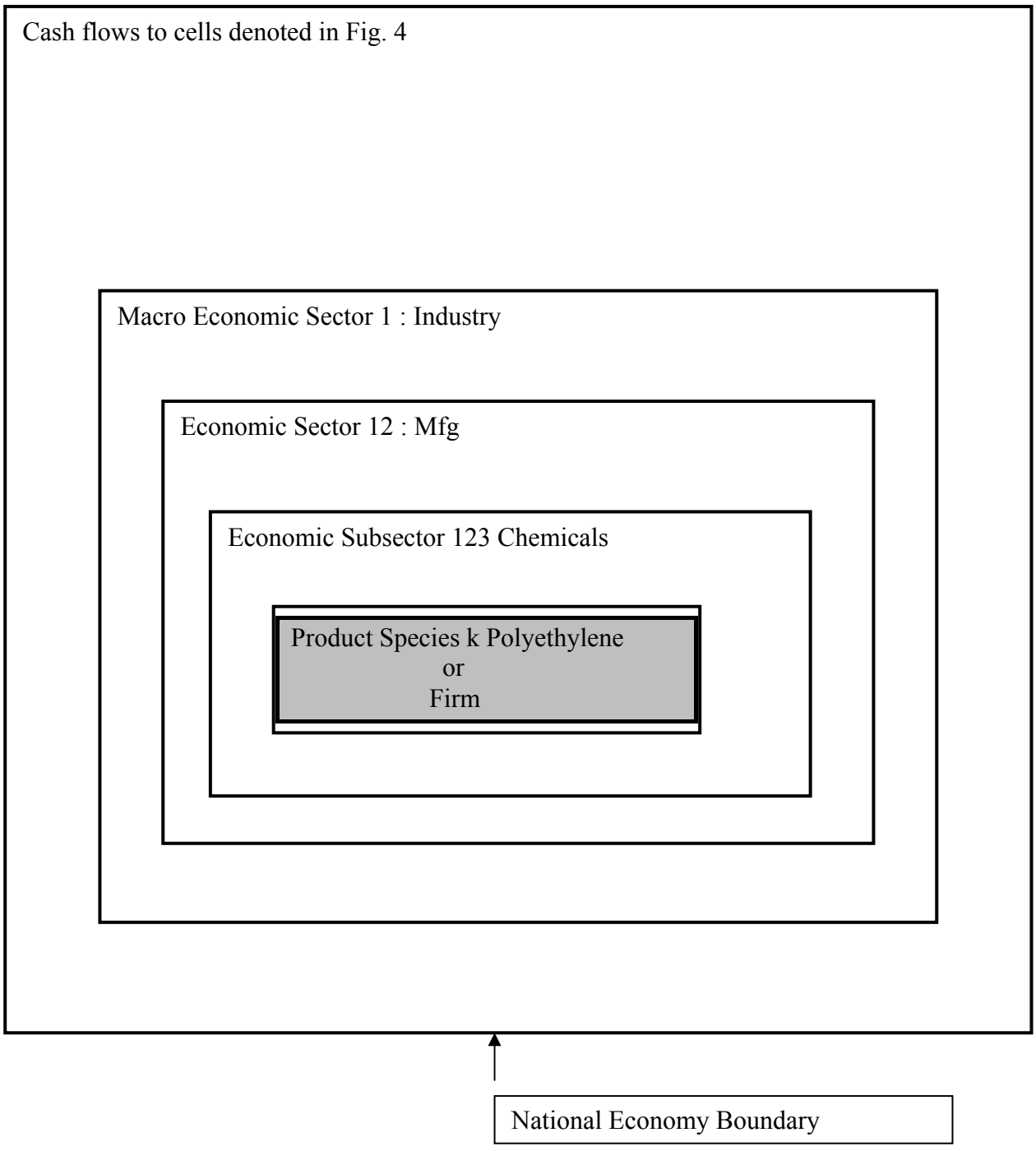


Figure 3: EEM Cell Structure

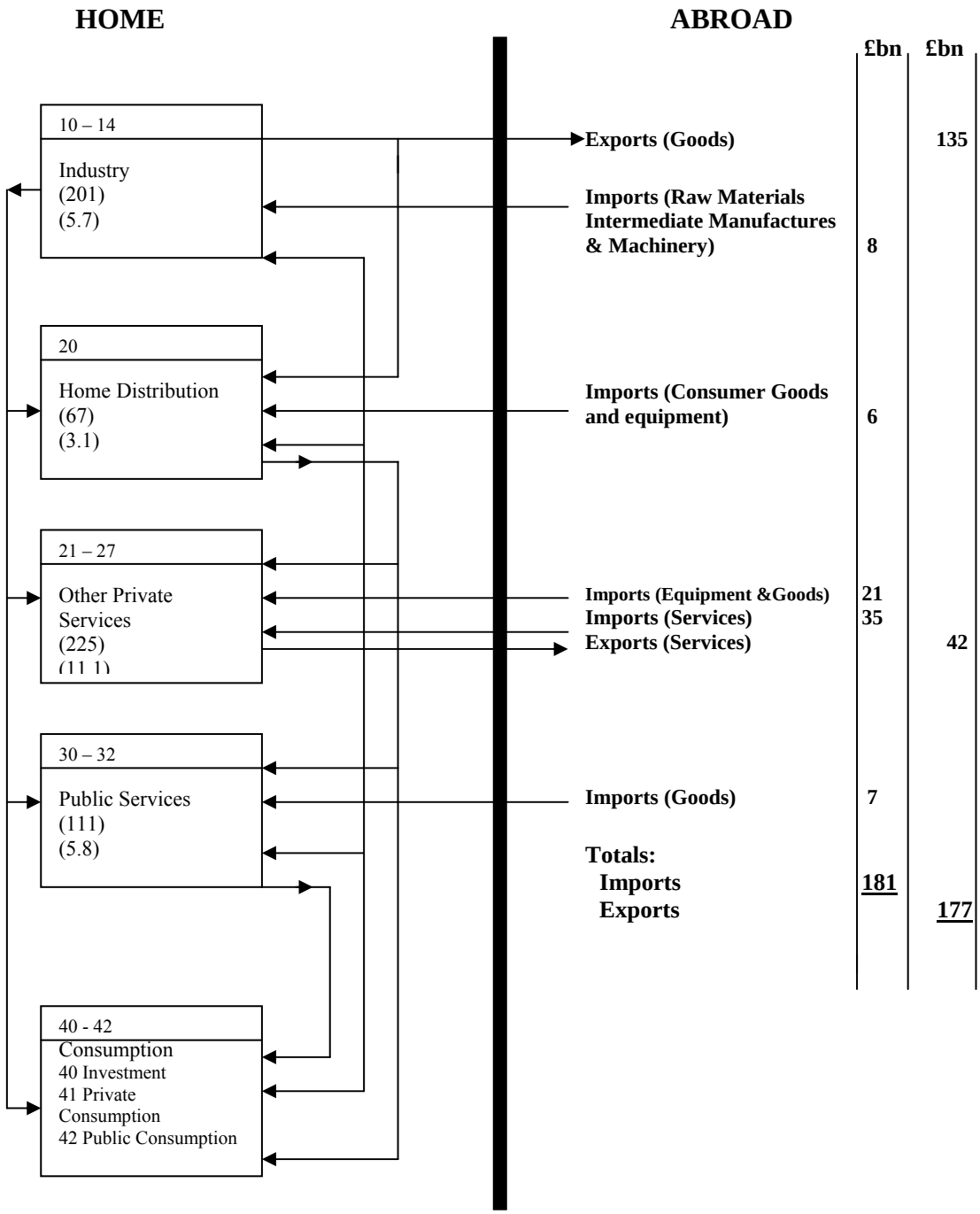


Fig 4: Flows (£bn) between some sectors and macrosectors of the economy 1994.

Two digit numbers in boxes correspond to sectors in Table 3. Bracketed figures are: upper - cost of output (added value) £bn and lower – millions of people employed.

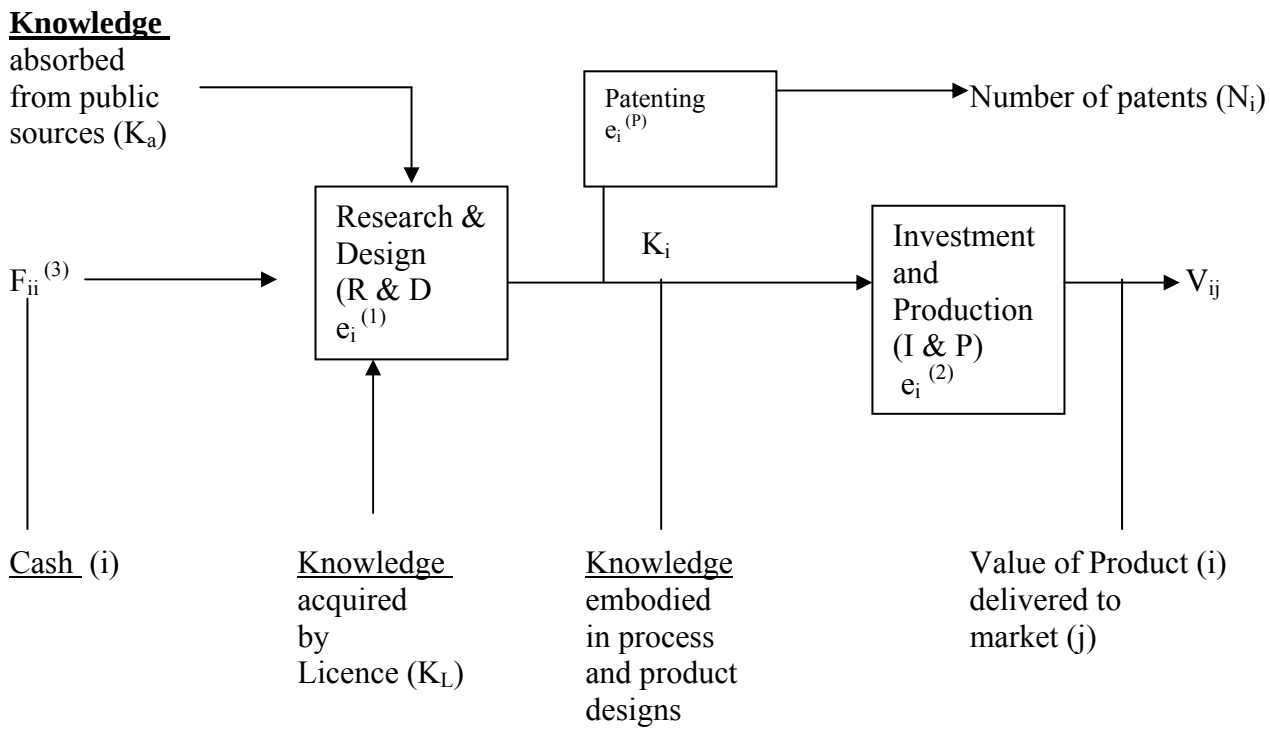
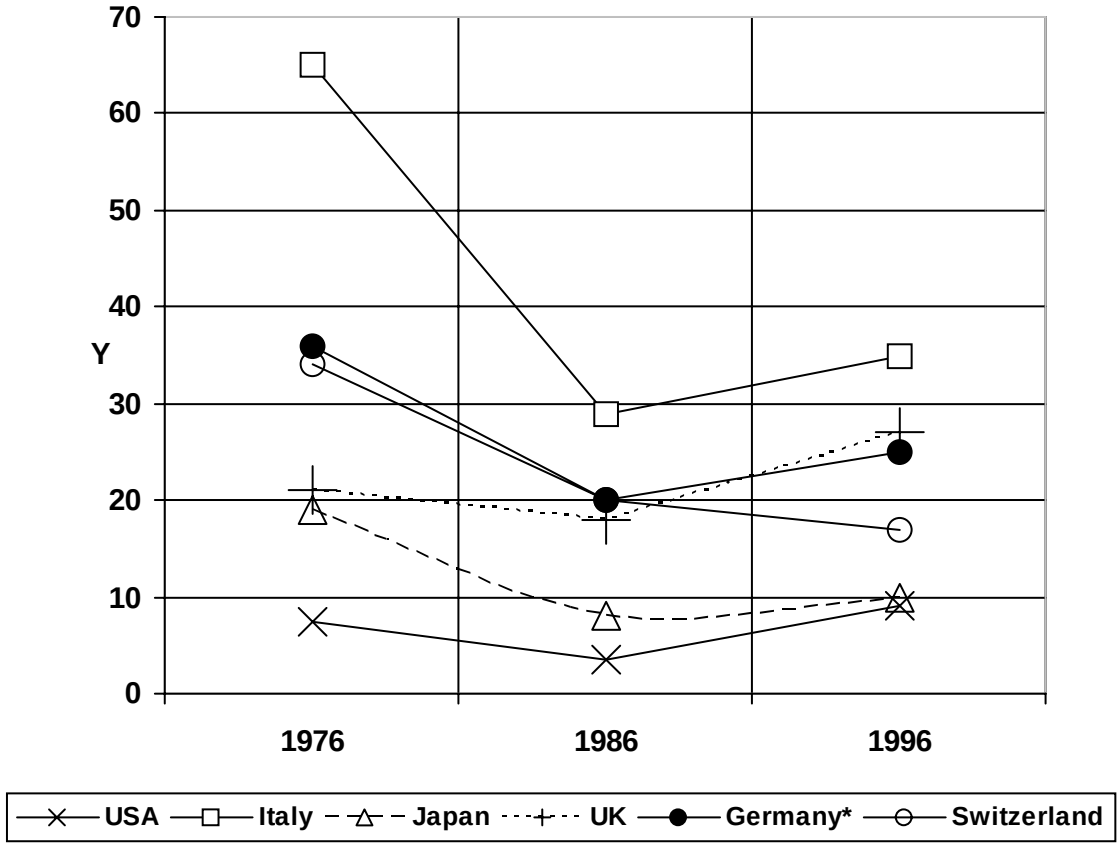


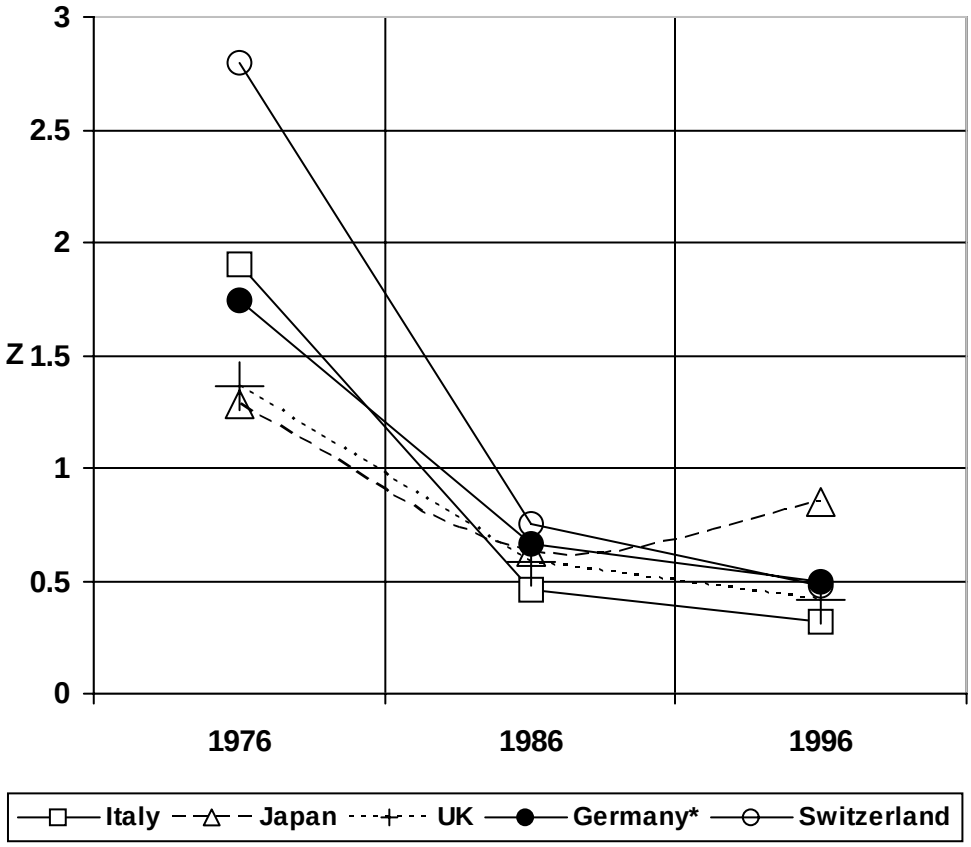
Fig. 5 Simplifed model for converting cash spent ($F_{ii}^{(3)}$) on Research and Design, (R & D) into product value (V_{ij}) for country or industry (i) in market (j)

Figure 5: Simplified model for converting cash spent (U_i) on Research and Design, R&D) into product value (V_{ij}) for country or industry (i) in market (j) and market share (S_{ij})



*West Germany up to 1990

Figure 6: Annual Export Sales of Manufactured Goods per unit of R&D Expenditure (e_i) 1976-1996



* West Germany up to 1990

Figure 7: U.S. Patents filed per million $ of R&D (g_i) for various countries 1976-1996