THE SCOTTISH "ELECTRONICS" INDUSTRY[1]

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1. Introduction - The Three Waves

In the mid-1980s the electronics industry has been hailed a Scottish manufacturing success story. According to one source (F Roberts[2]) it represented 1.1% of total Scottish manufact employment in 1959 whereas by 1983 it accounted for 9.9%. Howeve nine-fold increase in share of total manufacturing employment only re an absolute increase in employment terms of 5.7 times ("electr employment growing from 7,400 in 1959 to 42,500 in 1983). Furthe one firm, Ferranti, accounts for over 7,500 of this total, or 17.6%. following chapter we shall discuss in turn a number of important aspe the Scottish electronics industry e.g. employment, output and trade, a as some of the disturbing issues which have been ignored in the eup surrounding the industry's 'rapid growth'. These will be exa presently but first a brief history of the development of electron Scotland is in order.

The first wave

The forerunners of the modern Scottish electronics business app in two distinct waves of inward investment. The first wave started d the second world war when Ferranti set up its first Scottish fact Edinburgh to manufacture gunsights. After the war there was an inf US multi-national enterprises (MNEs) which located right acro industrial central belt of Scotland – from National Cash Register in D to International Business Machines in Greenock. NCR arrived in 19 was followed by Honeywell (1948), Burroughs (1949) and IBM (amongst others. These MNEs were primarily involved in manufac electro-mechanical products, from time-clocks and cash registers first generation of computers. As such they employed mostly skille semi-skilled male labour with a predominantly engineering backgr Unlike more recent start-ups in the electronics industry, this domination has stayed with these companies to the present day. A contrast to more recent 'incomers' the majority of these firms were, a

are, unionised (the most notable exception being IBM[3]). In the past, Burroughs, Honeywell and NCR have had their fair share of labour difficulties which have contributed to the long-held fears on the other side of the Atlantic that Scotland was a country of militant trade unionists and, therefore, not a good investment option. While there seems to be no doubt that the experiences of these firms did have an effect on the investment decisions of a number of their more timid compatriots the record of IBM in Greenock has done much to dispel the myth. IBM maintains that it is not anti-union (indeed, some of its workforce remain members of trade unions) but equally, it refuses to recognise single or joint trade union negotiating rights. There have been no major disputes in the company's thirty-odd years on Scottish soil a record which largely reflects the firm's package of benefits, rates of pay and guarantee of a job-for-life. In the second wave of inward investment, the non-union IBM model was adopted by most of the incoming firms.

The second wave

The first wave of inward investment had established some of the strongest original equipment manufacturers (OEMs) in Scotland. However, most of the components and sub-contract work required to service these giant electro-mechanical firms was, by necessity, imported. In contrast, the second wave of inward investment in the late 1960s brought with it the basis for the important components industry which is still strong in Scotland today. Again the inflow was dominated by US firms – Motorola, General Instruments, Hughes Microelectronics, National Semiconductor and Hewlett Packard. While the last named added to the industrial products and information systems sector of the Scottish industry the other four all brought with them the new 'solid-state technology' which was replacing the old diodes, valves and wiring of the early giant (in physical terms) computers. These companies utilised semi-conductor materials to manufacture transistors – the immediate predecessor of today's integrated circuit or microchip.

This period of active inward investment took place during the phase of strong regional policy as enacted by the Wilson government. Retrenchment in the industry followed in the early to mid-1970s and employment fell from a peak of around 49,000 in 1970 to just under 31,000 in 1978 (Crawford[4]). Latest estimates (Industry Department for Scotland[5]) place employment in the industry at 45,800 still some way short of the 1970 peak.

The third wave

Perhaps one of the major factors drawing attention to the electronics industry over the last few years has been the sector's continuing growth while other manufacturing industries have declined or stagnated (thus accounting for the industry's ninefold increase in the share of Scottish manufacturing employment since 1959 while in absolute numbers the workforce has increased by less than sixfold). The IDS claims that output in the industry more than doubled in the period 1978 to 1984 (although difficulties with definitions and re-classifications open this figure to some question). At the same time the Scottish Development Agency has been successful in attracting well-known, established names in the electronics industry world-wide to Scotland. As in the other investment waves these firms have been mostly American but two notable Japanese enterprises – Nippon Electric Company and Shin-Etsu Handotai – have been among them. All major aspects of the electronics industry have emerged in Scotland; from electronic data processing equipment to optical precision instruments. Expansion in existing electronics firms has been a characteristic of this development.

The predominant position of electro-mechanical engineering became a casualty of the disinvestment of the 1970s and the picture in Scotland today is of a highly electronic-orientated workforce concentrated mainly in the defence, industrial and semiconductor/components sectors.

2. The structure of the industry today

One of the most important aspects of the phenomenon known as 'Silicon Glen' is the concentration of electronics and electronics-servicing firms in an area 80 miles long by 30 miles wide. There are now around 300 firms in this central belt of the country which is similar in size to one county in the large American states. This concentration can be contrasted with the fact that in the US these counties often have one, or at most, two firms located in them. In this section the main features of the industry, employment, output and trade, will be reviewed.

Employment

It should be noted first that, in discussing changes in employment in the Scottish electronics industry over time, there have been a number of revisions and re-classifications of the government's Minimum List Headings (i.e. the most detailed breakdown of employment and output available from official sources). Under the 1980 Standard Industrial

Classification the electronics industry is split into 10 Activity Headings as shown in Table 1.

TABLE 1

Current electronics industry Activity Headings

3302	Electronic data processing equipment
3433	Alarms and signalling equipment
3441	Measuring, checking and precision instruments and apparatus
3442	Electrical instruments and control systems
3443	Radio and electronic capital goods
3444	Components other than active components
3453	Active components and electronic sub-assemblies
3454	Electronic consumer goods
3710	Optical precision instruments
3732	Telegraph and telephone apparatus and equipment

With respect to these headings the IDS (IDS[6]) have estimated electronics employment for selected years between 1978 and 1984 using the Census of Employment and Regional Data Systems. These data are shown in Table 2.

TABLE 2

Estimated electronics employment 1978-84 : by industry grouping

	Employees in employment from:			
	Census of Employment		Regional Data Systems	
Industry groupings	**1978**	**1981**	**1983**	**1984**
Electronic data processing equipment*	8,100	7,100	8,700	9,400
Electronic components**	9,600	8,400	9,700	10,500
Electronic instruments engineering‡	6,600	5,700	5,400	5,400
Other electronics‡‡	13,000	17,100	20,100	20,500
All electronics sector	37,300	38,300	43,900	45,800

Note: * Activity Heading 3302
** Activity Headings 3444, 3453
‡ Activity Headings 3710, 3732
‡‡ Activity Headings 3433, 3441, 3442, 3443, 3454

Source: IDS Statistical Bulletin

The resulting estimates suggest increases in employment in all industry groupings except electronic instruments engineering over the period 1978-84, with the increase for electronics as a whole being of the order of 23%. However, the extent of employment expansion in the sector is a subject of some debate. Data from an alternative source, the Engineering Industry Training Board, paint quite a different picture (see Table 3).

TABLE 3

Electronic and related industries employment, 1978/83 (SIC, 1980)

Industry grouping	**Employment in Scotland**	
	April 1978	**April 1983**
Office & data processing equipment	10,940	8,671
Basic electrical equipment	7,881	5,151
Electronics*	23,997	24,480
Other electrical engineering	18,407	6,185
Instrument engineering	11,806	7,656
Total‡	**73,031**	**52,143**

Note: * EITB definition
‡ Office machinery and data processing equipment, Electronic amd electrical engineering and Instrument engineering

Source: EITB Statutory Returns

Using a wider SIC definition, the EITB estimates employment in electronics and related industries as having fallen from 73,031 in April 1978 to 52,143 in April 1983 (a decrease of 28.6%). Only the electronics sector displayed an increase in employment over the period, and that of only 2%. How can these two sets of figures be reconciled? The stock answer is that they cannot. There are, however, sufficient grounds for caution with respect to the considerably more optimistic IDS figures which, as IDS concedes, are compiled from a number of sources and are subject to reclassification according to current production patterns[7]. It is worrying from the point of view of forecasters and serious commentators on the Scottish economy that two reputable sources of information should provide such widely differing estimates. However, given that most previous employment estimates have been based on IDS figures we must accept these for the purposes of comparison. In so doing, a picture of the regional distribution of electronics employment in Scotland in the two years 1976

and 1984 can be drawn (see Table 4).

TABLE 4

Estimated employment in electronics in Scotland by Local Authority Region, 1976/84

	Estimated total electronics employment			
	1976		1984	
Region	**Number**	**%**	**Number**	**%**
Strathclyde	18,000	50	19,100	42
Lothian	8,640	24	11,000	24
Fife	6,120	17	8,500	19
Tayside	1,080	3	4,300	9
Borders	1,080	3	2,900	6
Rest of Scotland	1,080	3	—	—
	36,000	100	45,800	100

Sources: 1976, Scottish Economic Bulletin No.16
1984, IDS, Statistical Bulletin

This table displays that there was a fairly high degree of stability in the proportions of employment in each region between the two years. However, there was a slight shift in employment from the west to the east coast regions. Whereas Strathclyde's employment share has dropped by 8% (although in absolute terms the number employed has increased marginally), the Fife and Tayside shares have increased by 2% and 6%, respectively. Within all of these regions employment is concentrated in a number of towns and industrial estates e.g. the new towns of Glenrothes (Fife), Livingston (Lothian), Cumbernauld, East Kilbride and Irvine (all Strathclyde) have successfully attracted many inward investment companies. One of the main reasons for the shift in proportions from west to east coast regions is the fact that Glenrothes and Livingston have attracted mainly new, high growth electronics firms during the third wave of investment. On the other hand, many of the first and second wave electro-mechanical employers settled in the new towns on the west coast (nearest Prestwick airport and America) and therefore Strathclyde has experienced a much slower rate of employment growth because incoming electronics firms are often making up the job numbers which the electro-mechanical producers have shed.

Employment is also concentrated in the industry in a number of

sectors. A sectoral breakdown of employment was provided for 1983 by the Scottish Development Agency (SDA[8]) and is shown in Table 5.

TABLE 5

Sectoral spread of electronics employment (1983)

Source	**%**
Industrial, commercial and telecommunications	25
Defence electronics	25
Information Systems	22.5
Semiconductors and components	17.5
Sub-contracting	7.5
Consumer sector	2.5
	100.0

Source: Scottish Development Agency

Highlighted in this table is Scotland's relative weakness in sub-contracting – an indication of the central buying policy of many of the OEMs sited in the country. However, it is also the case that many large electronics concerns (e.g. IBM), restrict the amount of sub-contracting services they buy from any one supplier to between 20-30% of the sub-contractor's output. This safeguards the sub-contractor in that it reduces the risk of closure born of dependency on one or two major customers but, at the same time, makes it difficult for small, indigenous firms of this type to emerge. The SDA and government are now focussing attention on ways of alleviating this imbalance but it is too early yet to detect real signs of success.

McCulloch points to another important feature of the Scottish industry:

> "It should be noted that employment in the defence systems, information systems and semiconductor market sectors is primarily with large MNCs, whereas in the industrial and commercial support components sectors, the average company size is very much smaller."(McCulloch[9])

During 1984 there was rapid growth in the semiconductor and

components sectors which appeared to establish the potential for a higher employment share than 17.5%. However, the semiconductor industry experienced considerable difficulties during 1985 (see section 3) and over 1,000 jobs were lost in this sector alone. It must also be borne in mind that the majority of jobs in the defence sector is due to three firms – Ferranti, Barr & Stroud and Racal-MESL – whereas around 300 firms account for the employment in the remaining sectors.

The heterogeneity of the industry is perhaps best illustrated by breaking down employment by country ownership as in Table 6.

TABLE 6

Employment by country ownership and number of firms, 1983

Location of ownership	Number of firms	Average number of employees
Japan	2	179.0
Europe	6	66.5
U.S.A.	34	511.4
Rest of UK	49	354.5
Scotland	178	39.4
Total	**269**	

Source: Scottish Development Agency

From the table it can be estimated that although there were only 34 US firms (not plants) in Scotland, they accounted for 40% of electronics employment i.e. they are large employers. On the other hand, the 178 Scottish-owned firms accounted for only 17% of employment and had by far the lowest average number of employees.

Two final features concerning the composition of employment in the Scottish electronics industry are worth considering: the degree of technical and support staff and the ratio of female to male labour.

The SDA (SDA[10]) claimed that, in 1978, scientists, technologists and technicians accounted for 22% of the electronics workforce. By 1981 this figure had reached 26% and was expected to touch 30% in 1985. Evidence from the Engineering Industry Training Board goes some way towards reinforcing these claims for electronics, and office machinery and data processing equipment in particular. The occupational structure of electrical, electronic and instrument engineering in Scotland as at April 1983 is shown in Table 7. From this table we can see that the two sectors –

electronics, and office machinery and data processing equipment – have 22.1% and 27.8% of their workforces classified as scientists, technologists and technicians (the sum of rows 2 and 3). This is noticeably more than, for instance, basic electrical equipment (10.6%), a more traditional sector serving the electricity supply industry which reflects the craft and occupational structure of industries such as mechanical engineering.

TABLE 7

Occupational structure of electrical, electronics and instrument engineering in Scotland (April, 1983)

	Percentage in each occupation				
	Off.mach/ry & data processing	Basic electrical equipment	Electronics*	Other electrical engineering	Instrument engineering
1 Managerial	8.7	5.3	4.7	5.1	3.9
2 Scientists & technologists	16.7	1.0	7.1	1.5	6.2
3 Technicians	11.1	9.6	15.0	4.8	10.7
4 Admin. & Prof.	11.0	4.8	5.9	7.2	6.4
5 Clerks, typists etc.	12.7	8.0	9.6	9.5	9.6
6 Supervisors & foremen	3.6	4.2	4.7	5.4	3.9
7 Craftsmen	4.4	30.8	9.0	9.5	14.1
8 Operators	27.4	32.6	39.3	53.7	40.2
9 Others	4.4	3.5	4.7	3.3	5.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Note*: Definition of electronics used by EITB. It excludes data processing equipment, alarm and signalling equipment, measuring and optical instruments but includes records and pre-recorded tapes.

Source: Engineering Industry Training Board

If, as the SDA claim, the occupational structure of the electronics industry (corresponding roughly to columns 1 and 3 in Table 7) is becoming more highly skilled, then a number of issues are raised. Most importantly, it must be considered whether Scotland is well-equipped to meet the demand for higher skills. Secondly, there is the question of whether if high wage, skilled labour is taking an increasing share of total electronics employment,

other occupations are being squeezed to make way for them. The first question will be re-addressed in section 3 but here we shall concentrate briefly on the second.

It is not necessarily the case that, as the proportion of scientists, technologists and technicians grows, the absolute numbers in other occupational grades will fall. However, one of the main reasons for a growing high skill element in the workforce is the degree of automation being introduced into the industry. In the present day electronics industry automation is particularly affecting the labour intensive assembly operations e.g. automatic machine insertion is taking over from hand population of printed circuit boards and the surface mounting technique of fixing microchips to these boards growing at the expense of flow-soldering and manual operations. One section of the workforce which these developments are likely to hit first is that dominated by female workers – the semi-skilled assembly tasks area.

In some firms in the industry (especially in integrated circuit and assembly unit production) the female component of the labour force is as high as 75%. Often the tasks women are asked to perform require a high degree of manual dexterity and repetition. Many managers believe that women cope better with the high boredom factor in these operations although this appears to be based on amateur psychology rather than scientific fact.

In assisted areas, of which Scotland is one, official figures, contained in Cooke et al[11], have estimated female employment at 74% of all manual production workers (falling to 48% in non-assisted areas). However, developments in the industry are leading larger electronics firms to shed unskilled labour and increase the demand for semi-skilled and skilled technicians and engineers. The future demand, therefore, for unskilled female (and male) labour looks set to fall and, indeed, current employment levels may be difficult to maintain.

Ownership

It follows from the development of the Scottish electronics industry that much of the ownership of the industry lies outwith Scottish and, indeed, UK hands.

TABLE 8

Employment by country of ownership (%)

Country	Employment
Japan	1
Europe	1
Scotland	17
US	40
UK	41

Source: Scottish Development Agency

Only 17% of electronics employment is in indigenous Scottish companies and the US rivals the UK for top spot in employment share (as Table 8 shows). This share mix is in part a reflection of the success of the SDA's campaign to bring inward investment in high technology companies to Scotland but, as we have seen, multinational investment (particularly from the United States) predates by a long way the Scottish Development Agency.

Many worries have been expressed at the degree of multinational control in the Scottish electronics industry. Politicians and trade unions, in particular, seem concerned at the influence these companies have and their 'notorious' nomadic qualities. While it is the case that a number of MNEs have closed or reduced their operations in recent years (e.g. Standard Telephone and Cable, ITT, Singer, Hoover, Burroughs, Honeywell, General Instruments and Timex) this is true also of a vast number of indigenous, UK and public firms. Indeed, Rada[12] makes it quite clear that the electronics and information technology markets are singularly distinguished from past innovations in that only if they operate on a world level can they become economically efficient. The price for a reduced role of MNEs in the Scottish industry would be a loss of status in the world market and the possible collapse of the servicing and components elements of the industry altogether.

Furthermore, there is little or no evidence to date to suggest that US multinationals regard Scotland as merely a 'staging post'. They have, more often than not, located in Scotland to serve not only the UK but the European market (as the fact that in 1983 Scotland was producing 21% of Western Europe's semiconductor output while having only 1.5% of its population clearly shows). The US multinational presence in Scotland is a mature and welcome feature of our economic and industrial life. In the

electronics business it has acted as a catalyst to research and development (which has led to world leadership in areas such as optoelectronics and artificial intelligence) while in the economy in general it has not only brought much needed jobs and investment but new work practices and managerial philosophies which, if not always successful or desirable, are at least stimulating and thought-provoking.

Major products and markets

The electronics industry is, like most industry groupings, heterogeneous. As Levidow and Young[13] point out, heterogeneity stretches to the spatial dimension also.

> "...software production is focused on the high-wage areas such as London and the Home Counties in the UK, whereas micro-electronic hardware production has been drawn to the low-wage areas such as South Wales and Scotland." (Levidow and Young (eds))

This quotation indicates exactly where Scotland's product strength lies – in hardware and systems manufacture. Disaggregation reveals that the 'big four' product areas, in terms of employment, are industrial products, information systems, defence and avionics, and electronic components (see Table 9). Together these accounted for 77.6% of total electronics employment in 1983. The defence and avionics component is comprised mostly of mature investment and has expanded little in recent years. The electronic component product area (including semiconductors) is also technically very well advanced. Every semiconductor firm in Scotland undertakes wafer fabrication i.e. they are located at least at stage 3 in the stylised 'sophistication' ladder shown in Table 10.

In many less developed countries semiconductor producers operate mainly at stages 1 and 2. A mark of the sophistication or maturity of a country's semiconductor industry is indicated by movement through the various stages of product development. In Scotland's case some firms have even reached stage 5 e.g. Motorola and National Semiconductor, but to the best of our knowledge stage 6 is still confined to parent firms in the US and Japan.

The SDA considers that there are four areas where future electronics developments in Scotland will be particularly strong: semiconductors, very large scale integration (VLSI), artificial intelligence (AI) and opto-electronics. NEC and Digital are carrying out research into VLSI and

Edinburgh University's Wolfson Institute (now Wolfson Microelectronics Limited) has built up world leading expertise in AI and optoelectronics over the last 15 years. Furthermore, the SDA have also forecast growth rates in the European market over a range of products (see Table 11). These forecasts were based on market size in 1983 and project the then expected total increase in demand to 1986.

TABLE 9

Scottish electronics industry by produce area, 1983

Main product area	Number of companies	Number of employees	% share of total electronics employ
Industrial products	82	8,984	21.1
Information systems	24	8,880	20.9
Defence and avionics	9	7,739	18.2
Electronic components	52	7,406	17.4
Telecommunications	14	3,961	9.3
Electric sub-contracting	46	2,507	5.9
Consumer products	11	2,048	4.8
Design services	17	596	1.4
Medical electronics	14	402	1.0
	269	42,523	100.0

Source: SDA Survey [14]
Table first published in Firn and Roberts

TABLE 10

The semiconductor industry: stages of development in inward investment receiving countries

1. Warehousing and marketing functions
2. Assembly plant
3. Low-volume wafer fabrication
4. High-volume wafer fabrication
5. Silicon foundry work and design capability
6. World product responsibility

TABLE 11

European market increase in demand 1983-86 by product

Product	Demand increase %
Data processing equipment	63
Office equipment	27
Control and instrumentation	25
Medical and industrial	23
Communication and military	30
Telecommunications	26
Component	34
Consumer	19

Source: SDA slide presentation

Undoubtedly the current recession in the semiconductor market has adversely affected the estimate for components. If, however, the other forecasts are at all accurate Scotland is in a good position to further increase the size of its electronics industry as a result of its relative strength in the reputedly fast-growing product areas of data processing and communication and military equipment.

Firn and Roberts[15] claim that, in total, 38% of Scottish electronics production is exported whereas a further 55% goes to the UK market other than Scotland. These estimates are somewhat different from the corresponding proportions derived from the two Scottish Input-Output studies for 1973 and 1979 as indicated in Table 12.

In 1973 imports from the rest of the UK formed 71.4% of total Scottish electronic and communications equipment inputs. By 1979 this had fallen to 23.8% reflecting the upsurge in Scottish component, sub-contracting and service firms. The rest of the world import content had stayed fairly stable at 19-20%. However, exports to the rest of the world in the two years were substantially higher than the Firn and Roberts estimates i.e. rising from 45% of output in 1973 to 52.2% in 1979, with RUK exports falling back from 43.4% to 34.5% over the same period. Since the electronics industry has become, if anything, more export-oriented in the last few years the Firn and Roberts figure for ROW exports begins to look like an under-estimate. The discrepancy is most probably explained by the fact that some of the rest of the UK (RUK) trade reported in the Firn and Roberts study may be exported at a later date.

It is clear that the Scottish electronics industry enjoys a healthy trading surplus. Exports to the rest of the world outweighed imports from the rest

of the world in both 1973 and 1979 and the trade balance with the rest of the UK moved from deficit to surplus between the two years.

TABLE 12

Scottish electronics industry trade flows 1973 and 1979 (% of total output)

	1973*	1979**
Imports (RUK)	71.40	23.80
Imports (ROW)	19.00	20.00
Exports (RUK)	43.40	34.50
Exports (ROW)	45.00	52.20
Total Output/Input‡	£326.47m	£813.40m

Note *Comprises communications equipment and computers and electronics
**Includes activity headings 3302, 3433, 3442, 3443, 3444, 3453, 3710, 3732
‡These figures are in current year prices as at the date of the study.

Sources: Input-output tables for Scotland[16]

It appears, therefore, that the electronics industry is a major contributor to the health and robustness of the Scottish economy in terms of employment, investment, trade, research and development as well as with respect to the less tangible aspects of new work philosophies. However, the industry has suffered a variety of 'growing pains' and setbacks. It is to these that we now turn.

3. Growing pains and other maladies

As mentioned in the introduction to this chapter, there have been a number of disturbing issues recently which have tempered claims that the Scottish electronics industry is in an unstoppable virtuous growth circle. In the following section three constraining aspects of the industry are considered.

The semiconductor slump

The semiconductor industry worldwide had its best ever year for sales and growth in 1984. Sales worth around $25bn were recorded and a further

22% growth was forecast by the Semiconductor Industry Association for 1985. Orders (bookings as they are referred to in the industry) exceeded $1,200m in the United States at the beginning of 1984. However, by January 1985 orders had slumped to around $600m in the worst market fall in the industry's history. Particularly badly hit were the giant US multinationals, many of whom form the backbone of the Scottish industry.

The slump was caused by a mismatch of demand and supply which resulted as a consequence of one of the congenital weaknesses of the electronics industry – over-optimism. The central problem arose in the home and personal computers market. Around 20 or so manufacturers were each aiming to take 25-50% of the market in the US and planned production accordingly[17]. As personal computer makers increased production, lead-times on the supply of microchips increased. This in turn caused other manufacturers, such as mainframe computer makers and telecommunications suppliers, to re-order early thus exacerbating the position. When the expected boom failed to materialise in the PC market excess demand quickly shifted to excess supply and, even with cuts of 40-50% in the price of a single chip, the market collapsed. The position for semiconductor firms was made even worse by the appearance of a large resale market made inevitable by the bankruptcies of the unsuccessful PC makers. The American market felt the recession most keenly. Up to August 1985 over 5,000 US jobs had been lost in semiconductor firms: 3,000 at Texas Instruments, 1,000 at National Semiconductor, 900 at Intel and 600 at Micron Technology. Scotland too suffered. However, contrary to the conventional wisdom on the 'branch plant syndrome' Scottish-based MNEs have faired better than their US bases.

The first casualties of the recession were the proposed expansionary investments at Motorola (£60m) and National Semiconductor (£100m). The firms maintain that these are just postponements and that the commitments to invest still stand but only time will tell. As 1985 progressed a variety of schemes were introduced in semiconductor firms to cut down output and reduce stocks. For example, short-time working, longer holidays, a reduction in shiftwork and voluntary severance schemes were all implemented. Nevertheless National Semiconductor announced 450 job losses at their Greenock plant during the summer thus bringing the workforce down to 1,100 (200 additional jobs had been lost through natural wastage). At the same time Timex in Dundee announced 400 redundancies due to the fall-off in orders for the Sinclair home computers produced in the factory. By the end of the year, the worst seemingly over, the bombshell of the first major closure in the Scottish semiconductor industry burst. General Instruments, based in Glenrothes, was one of the first semiconductor firms to arrive in Scotland during the 1960s and their position in the market relative to the large, standardised chip manufacturers such as Motorola and National Semiconductor, seemed fairly secure. Like Hughes Microelectronics and Burr-Brown, General

Instruments produced custom and semi-custom made chips for the 'higher end' of the market. One reason forwarded for their closure was that standard chip prices had fallen by so much that it was cheaper for customers to array a number of these chips in a certain way than to pay the price for the more specific, customised components. Whatever the reason, the General Instruments closure shook confidence in the industry.

The largely unforeseen recession demonstrated the dangers of forecasting in such a 'leading edge' industry. In 1983 it was estimated that the Scottish semiconductor workforce of 3,564 would almost double by 1986 (SDA Locate in Scotland[18]). Levels of employment in 1983 and the SDA projections are shown in Table 13 along with employment in the sector as at January 1986.

TABLE 13

The Scottish Semiconductor industry

Company	1983 Employment level	1986‡ Projection	1986 Actual
Motorola	1,259	2,100	1,200*
National Semiconductors	1,300	1,800	1,100*
NEC	170	650	250*
General Instruments	250	650	–
Hughes Microelectronics	547	600	600*
Burr-Brown	38	700	150*
	3,564	6,500	3,300

Note: ‡ Projections taken from SDA/LIS
Asterisks represent estimates from recent announcements where possible.

As the table shows, rather than the projected doubling of employment in the industry some workforces were more or less static and others had grown by much less than forecast. In the case of General Instruments the firm had closed completely.

There have been some signs that the worst of the recession may be over. In September 1985 the book-to-bill ratio (the industry's leading indicator) moved up for the first time in a year. The Semiconductor Industry Association forecast rapid sales growth worldwide of 18% in 1986 (although of only 7.8% for the European market which the Scottish industry serves). Furthermore, in the first quarter of 1986 National Semiconductor began to re-employ some of its workers laid-off during the previous year. In the medium to long term, however, employment prospects in the Scottish-based industry may be diminished by

developments on two fronts. First, there is the threat to US firms and their branch plants posed by the recent heavy investment undertaken by competing Japanese firms such as NEC and Hitachi. NEC have developed the 'V' series of microchips which are compatible with IBM products and as such will be in direct competition with Motorola's 'H' series. Although NEC has a facility in Scotland it is possible that if the Japanese were to take a large share of the semiconductor market, the job gains at NEC would be outweighed by job losses in US plantsserving the European market. Secondly, there have been fairly widespread developments in the automation of wafer fabrication and other processes. These are likely to reduce the degree of labour intensity in the industry and thus eventually lead to job losses.

Manpower limitations

Semiconductor firms are not the only examples where automation is proceeding apace in the electronics industry. In many respects this automation entails the application of microprocessor technology to the very industry which produces it. Apart from the fact that this development might cost jobs in assembly and testing it requires a higher level of skilled manpower to operate and develop the new processes. One of the questions asked of companies in the Scottish Business Survey produced by the Fraser of Allander Institute is, which of a number of factors is likely to limit your output over the next three months. In April 1986 14% of companies responded skilled labour and, in July 9%. Although this is anecdotal evidence in that the survey has only been running for two year, it is worth bearing in mind. Indeed, it has been a response which has occured systematically throughout the life of the survey. The Scottish Office (Scottish Economic Bulletin[19]) has given much emphasis to the question of manpower shortages, as has the UK Government. The report on electronics manpower in the mid-1980s suggested that over the decade up to 1983 the composition of electronics manpower had shifted towards graduate and technician manpower and this, coupled with similar demands from other industrial groups, had placed pressure on the supply of these skill groups.

For example, the Scottish Office estimated that in 1979, 1,900 engineers and 2,500 technicians were employed in electronics (representing 5.1% and 6.7% of the workforce, respectively). By 1985 these numbers were expected to have risen to over 3,000 in each of the categories (representing 8.3% of the total workforce in both cases) i.e. an increase in actual numbers of 37%. Furthermore, over the same period the demand for electronics staff in other manufacturing industries was expected to rise by 25%.

To accommodate these demands there are basically three sources of supply of skilled electronics manpower. First, there are graduates from

degree courses in the universities and technical colleges. In 1981/82 the intake for electronics degree courses was 780 (double that of 1975/6). More recently the government has made large scale finance available for just this type of course. Edinburgh, Glasgow, Heriot-Watt and Strathclyde Universities all shared in £28m worth of assistance advanced in 1984-85. Secondly, there are Higher National Diploma qualifications available at nine centres in Scotland and, although not considered on a par with a degree course, are more practical in nature. The student intake in 1982/83 for the electronics course was 345 (130 more than in 1979/80) and 166 awards were made in the same year. Lastly, SCOTEC courses (in electrical and electronic engineering) provide the main technical qualifications and are taught on a day-release or sandwich course basis. Over 1,000 certificate awards and around 500 higher certificate awards were expected between 1983 and 1987.

Despite these efforts the fact remains that strains are appearing on the Scottish skilled-labour market. These strains may lead to two things; first, higher salary offers to prospective and existing skilled staff in order to keep them, but secondly, to Scotland becoming a less attractive location for further investment as the manpower pool dries up and the labour cost increases.

The leading edge

One phrase often applied to the Scottish electronics industry is that it sits at the 'leading edge' of technology. This is meant to convey the ideas of frontier research, novel developments and sunrise industry. Indeed, the SDA and Scottish Office have used the electronics industry as a shining example of the new booming, thrusting Scottish economy. The former even employed the term 'critical mass', thus making the analogy that the Scottish industry has reached the stage of self perpetuation. Analogies between controlled natural science phenomena and the uncertain world of human relations, business and industry are always fraught with danger and deletion of this term from the SDA's publicity over the recent difficult period is of little surprise. Industries relying on leading edge technology face a double-edged sword. New ideas, high growth business and explosive profits have their counterpoint in the contribution of rapid technological change to uncertainty and the development of a highly volatile market. The 'leading edge' of technology, regardless of which industry is being examined, brings with it a high casualty rate as well as the opportunity for exceptional success.

Many firms in the electronics business find it difficult to keep abreast of new technology. They also require to be committed to continuing research, development and marketing efforts. It is therefore necessary, if the electronics industry is to remain as a countervailing force to the decline experienced in Scotland's traditional industries, that some public sector

involvement be forthcoming. One suggestion has been that the SDA should assist in providing venture capital for the fledgling domestic firms in the industry. In this way failures might be written-off without frightening off the investment trusts, banks and financiers indefinitely (or at least for the period of the crisis, recession or slump). In order that the SDA might play this role the government would have to remove the financial burden of achieving a high commercial rate of return on investments that it has placed on it. This type of commercial constraint breeds caution and inaction in the public agency and deprives leading-edge industries of the necessarily risky support they need. The SDA and government seem content to recognise only one leading edge – the successful one – but in order to maintain and nurture the industry the other edge must also be contemplated and accepted, if not welcomed.

4. Conclusion

The electronics industry is extremely important for the Scottish economy. Since 1975 the electrical and electronic engineering industry's output has doubled, although employment growth has been much less impressive. During the same period other manufacturing sectors have grown very slowly or indeed, declined e.g. mechanical engineering, shipbuilding, textiles and coal mining. But how has Scotland managed to attract such activity in this sunrise industry? Is it all down to public sector efforts?

Government policy has played a part. Until November 1984 almost all of Scotland was designated an assisted area under UK regional policy. In financial terms *regional development grants* of 22% on capital expenditure were available to companies announcing investment plans in Special Development Areas (this has now been cut to 15% on *new* investment only). This was complemented by the existence of *selective financial assistance* (available to both special development areas and intermediate areas) the level and composition of which was decided on various grounds, e.g. desirability of the new investment, number of jobs it would create, degree of complementarity it might bring to the region's existing industries, support for innovation etc. This measure still exists in designated areas. *Advanced factories* were also available in designated industrial estates (often near New Towns) and other incentives such as assistance with training and tax allowances were allowed on a discretionary basis. In Scotland the SDA, through the Locate in Scotland bureau, has a special role in detailing these financial and other incentives for potential inward investors in a fully-integrated package.

Since 1980 selective financial assistance from a number of central government schemes (eg. **Product and Process Development Scheme (PPDS)** and the **Micro-electronics Industry Support Programme (MISP)** the latter of which is now in limbo) has become available to non-UK electronics

companies. Indeed, Cooke et al [20] have shown that, especially US, inward investors have become the largest recipients of these funds. Despite this fact these firms claimed that such financial assistance has little impact on their future development or investment plans.

The new towns of Cumbernauld, East Kilbride, Glenrothes, Irvine and Livingston have development corporations which supervise the provision of industrial estates and the complementary amenities (including advanced factories) which go with them. Scotland also has three designated enterprise zones in Clydebank, Dundee and Invergordon, which offer further inducements to potential investors eg. rate-free letting for a period of years. In addition there are a number of area action schemes (eg. Glasgow Eastern Area Re-development project, Garnock Valley Action Area, Motherwell and District LIFE project) which are supported by the SDA and European Community grants as well as special funds such as the British Steel Corporation enterprise trust in the Garnock Valley. All of these quasi-public groups and funding sources are involved in increasing the level of amenities in various areas which help to make them attractive to industrialists and commercial concerns.

However, although such public sector support is important to inward investing firms other factors enter into the location decision.

For example, Scotland's traditionally skilled engineering labour force was a major attraction for the first and second waves of inward investment in electronics and electro-mechanical production. It is also the case that Scotland is a relatively labour-abundant region of the UK and as such has tended to be a relatively low wage region. These factors, high skill levels, (pressures on which now appear to be emerging as discussed in section 3), labour abundance and low wages (especially for unskilled and female labour), have been strong incentives for MNEs to locate in the area.

Academic reputation has also been a pull factor. The eight Scottish universities have a good reputation in both engineering and electronic research. In particular Edinburgh, Glasgow, Heriot-Watt and Strathclyde Universities have strong departments of direct relevance to the electronics industry, ranging from electrical engineering, computer science and physics to high quality research in artificial intelligence and opto-electronics. There is an active university-industry interface which involves academics in consultancy work, research projects in firms and industrialists participating in teaching courses at the various institutions.

One of the most important factors in Scotland's favour has been membership of the EEC. As a member Scotland falls within the tariff wall of the Common Market. The advantage of EEC membership is clearly shown in Table 14 which lists the current tariff rates on selected electronics products imported from non EEC sources.

TABLE 14

EEC tariff on electronic components and equipment

Product	Tariff (%)
Radio and communications equipment	9.3
Industrial control equipment	12.3
Electronic calculation machines	13.3
Semiconductors	17.0

Source: SDA presentation

Semiconductor firms in particular gain an advantage from being located within the EEC.

Further factors such as a plentiful pure water supply, a reliable supply of electrical power and good transport and communications links all add to Scotland's attractiveness as a location option.

Finally, a major inducement factor (if not incentive in itself) is the SDA and, in particular, its two divisions which are active in attracting overseas investment into the electronics industry – the *Electronics Division* and *Locate in Scotland*. The Agency gives fast access to detailed information on supplier companies, industrial developments and manufacturing processes in Scotland. It also screens companies as to their suitability for specific areas.

Firn and Roberts draw some conclusions about the way high technology industries should be supported:

> "...co-ordination of policy measures and attitudes across a wide range of activities including research, teaching and administration in all levels of education, the provision of more venturesome and flexible capital and management assistance from financial institutions, enhancing of management education and employee training, continued improvement of the physical environment, encouragement of changing social attitudes."[21]

To a large extent Scotland and the SDA are already meeting these challenges but more can always be done. To promote the sunrise into a new day will require money, patience and concerted government action.

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References

1. The term "electronics" industry must be used with some caution. Up until the late 1970s and early 1980s this industry was dominated by electro-mechanical and electrical engineering – which, in more ways than one, bore a strong resemblance to the mechanical engineering industry. Only since the third wave of investment has the "electronics" sector taken over as the major employer in the industry although, as is shown in the text, there are some doubts about the true definition of this term. These comments notwithstanding, it has become commonplace in Scotland to refer to the electrical and instrument engineering industry (which includes electronics) as the "electronics" industry.

2. Firn, J R and D Roberts, 'High-Technology Industries' in N Hood and S Young (eds.) *Industry Policy and the Scottish Economy*, Edinburgh University Press, 1984, p.298.

3. In a survey of electronics firms in the UK in 1984 it was found that trade unions were strongest in Scotland – more than 10% of the workforce was unionised in 59% of firms (Electronics Location File 1984).

4. Crawford, R "The Electronics Industry in Scotland", *Fraser of Allander Institute Quarterly Economic Commentary*, May 1984.

5. Industry Department for Scotland *The Electronics Industry in Scotland*, Statistical Bulletin, No C1.1, January 1986.

6. *ibid*

7. The IDS figures for 1983 and 1984 are based on Department of Employment estimates, *given production levels*, for those years. It is likely that these represent over-estimates of employment due to the spectacular growth in indices of production demonstrated by the Scottish electronics industry i.e. it has doubled over the period 1978-84.

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9. McCulloch, N A "The Structure of the Scottish Electronics Industry", *University of Edinburgh School of Engineering (Electrical Engineering)*, BSc Hons Dissertation HD314, May 1985.

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12. Rada, J *The Impact of Micro-Electronics*, International Labour Office, Geneva 1980.

13. Levidow, L and Young, B (eds.) *Science Technology and the Labour Process*, CSE Books, London, 1981, pp.172-207.

14. SDA (*op.cit*).

15. Firn and Roberts (*op.cit*).

16. Fraser of Allander Institute, Scottish Council (Development and Industry) and IBM (UK) Ltd *Input-Output Tables for Scotland, 1973,* Scottish Academic Press (1978).

17. To a lesser extent a similar over-optimism emerged in the UK market with firms like Sinclair, Acorn, Dragon, Oric etc. expecting to make much larger sales than they eventually realised. This led to massive discounting in the price of home computers and the eventual disappearance of Dragon and Oric.

18. Scottish Development Agency, Locate in Scotland, *The Semiconductor Industry in Scotland* 1983.

19. Scottish Economic Bulletin "Electronics Manpower in Scotland in the mid-1980s", *The Scottish Office*, No 28, December 1983.

20. Cooke et al (*op.cit.*).

21. Firn and Roberts (*op.cit.*)