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geschäftsführenderVorstand: Ass.Prof. Dr. Herwig Palme

A-1090 Wien, Augasse 2-6, Tel. (0222) 31 336/4777

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Ewan Sutherland*

Silicon Glenn; a technological Brigadoon?
an analysis of the electronics and IT industries in Scotland

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*Lecturer in informatics, St David's University College, Lampeter, Wales. This paper is based on a seminar held on Wednesday 16th December 1992. This is a preliminary draft - please do not quote or cite without approval from the author. However, comments and suggestions (polite or otherwise) are most welcome.

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Introduction

The Scottish economy has suffered severely throughout this century. The collapse of traditional heavy engineering industries has not been compensated for by the rise of other sectors, though A limited supply of good news has come from oil and electronics but this has proved to be shorter-lived than was initially hoped. So great was the apparent success of the electronics and IT industries that in the early 1980's that the most populous part of Scotland earned the designation Silicon Glen in imitation of California's Silicon Valley and in a desire to emulate its success.

The decline of traditional industries in the first half of the century was identified as requiring the introduction of new industries based on new technologies. As early as the 1940's efforts were made to build up the electronics industry in Scotland, though encouragement of indigenous firms has achieved little of lasting value. By comparison Scotland has been much more successful in attracting multinational corporations to build and operate factories. However, the same idea was adopted elsewhere, making Scotland part of a fiercely competitive market in locations; notable amongst the competitors has been Ireland and more recently Wales. Despite many years of work, no real differentiation has been achieved by Scotland in this marketplace.

The global semiconductor industry and the sectors downstream from it — computers, consumer electronics, telecommunications and so on — have endured continuous revolutionary change since the early 1950's. The result is that few firms have survived and no products. The dominance of the USA has been weakened with Japan, Korea and Taiwan having fought their way up to and sometimes beyond the level of the USA. Far from the Pacific Rim, the European industry barely warrants a mention, though the European market attracts global attention.

The structure of this paper is as follows:

- industrial revolutions
- the business of education
- communists and agitators
- government intervention
- the Agency
- a branch plant economy
- the Scottish electronics scheme
- the incomers

The latter includes a number of mini-case studies: NCR, IBM, Wang Laboratories, Rodime and Spider Systems.

Industrial revolutions

Checkland has characterised in stark terms the economic development of the period of more than a century when Clydeside was dominated by vertically integrated industry; iron to engineering and shipbuilding. During and after World War II it slowly began to be realised that:

> The upas tree[1] of heavy engineering had killed or discouraged the growth of other industries of a more modern kind beneath its massive and intertwined branches; now the upas tree itself, so long ailing, was decaying, its limbs falling away one by one. [Checkland, 1981, page 48.]

The strategic overcommittment to heavy engineering and shipbuilding meant that it took a long time to realise that something had gone wrong and to discover that the position was irrecoverable.

A 'Second Industrial Revolution' had occurred at the end of the nineteenth century, based on three industries:

- cars
- chemicals
- electrical equipment

The failure in Scotland to exploit the opportunities this created led to a seemingly inevitable economic decline. Industry was fixed in its historical pattern of iron and steel, marine and railway engines, shipbuilding and other forms of heavy engineering. The reputation of 'Clydebuilt' was achieved by industries that operated at the level of one-off and small batches in numberless yards and workshops. There was little understanding of mass production, distribution or advertising which were revolutionising industry in the USA and Germany. Neither had it been necessary to create a managerial cadre in the form of teams of expert managers running large corporations. Instead, the yards were dominated by strong-willed individualists (both owners and foremen) who, if abundant anecdotage is to be believed, could be myopic and parochial in the extreme.

In this second phase of industrialisation the performance of the UK differed considerably from that of the USA and Germany. Scotland and England generated few firms of comparable sophistication and those which did appear were generally smaller, without the same benefits of economies of scale and scope. A crucial difference was that the management teams were still dominated by the founding families where:

> ... selection to senior positions and to the board depended as much on personal ties as on managerial competence. The founders and their heirs continued to have a significant influence on top-level decision-making even after holdings in the enterprise were diminished ... outside directors were selected as much for family connections and social position as for industrial experience. [Chandler, 1990, page 242.]

Scottish and English firms were late in developing the administrative hierarchies commonly found in Germany and the USA; complex organisational structures which allowed them to exploit the new markets and master the new technologies.

The contrast is most obvious in Andrew Carnegie who emigrated from Scotland to the USA in 1848 aged 13. His industrial success was based on economies of scale, permitting low-cost production, allowing him to push down prices and so drive up demand, allowing a further increase in scale, facilitating further cost savings. Starting on a new site, he built the giant Edgar Thomson integrated steel works, producing steel rails from ore, including use of the new Bessemer smelting process. 'First mover' advantages were compounded by further innovations both small and large which continued to increase capacity and to cut costs. The scale of operations made it important to guarantee supplies, encouraging vertical integration into mining and coke production. Threatened by the upstream vertical integration of some of his customers Carnegie responded by proposing a yet bigger and

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1 The legendary Upas Tree of Java had the power to destroy other growths for a radius of fifteen miles.

more fully integrated works. Instead, Carnegie sold out to J Pierpoint Morgan for US$ 480 million (£89 million) in 1901, becoming one of the world's greatest philanthropists by giving most of the money away. [Livesay, 1975.]

By comparison, the Scottish steel industry was operating on a much smaller scale in individual plants and the degree of integration was much more limited:

> Collusion appears to have been endemic in the iron industry. Everywhere manufacturers sought to manage markets in their own interests, allotting fixed quotas to members, penalising those who overproduced to compensate those who underproduced. Small firms were thereby able to survive, but the attainment of economies of scale, the recruitment of better educated, more technically proficient and adventurous management, and the development of modern management practices were inhibited. Effective diversification was discouraged and economic growth retarded. Many firms established in mid-century had by its close come to be 'more interested in dividing the cake than in baking a new, larger, one'. [Payne, 1992, page 23.]

An integrated steel works was not in operation in Scotland until Ravenscraig in 1957, when it was far too late. Moreover, the Ravenscraig Steelworks was opened not to meet demand, but in order to stimulate industries which would provide the demand, relying on the plant achieving very low costs which in the event could not be achieved, primarily because of difficulties with the trades unions.

By the outbreak of the Second World War the flaws and failings of the Scottish economy could no longer be hidden. In terms of technology and management it had made little progress since the beginning of the century, while marketing was still seen as mere propaganda. The result was an absence of the economic growth necessary to sustain Scotland's place in the world and its growing population. The position of Scotland was at least as bad as any other peripheral region of the UK in terms of its economy. The state of industry and its ability to adapt and prosper were, arguably, worse. In particular the English Midlands had managed to move into the car industry. In addition to its strong sense of identity, Scotland was different from the other peripheral regions in the UK in having its own banking sector.

A sequence of crises befell the Scottish economy in the 1960's resulting from a number of factors including:

- the erosion of the position of the United Kingdom as a great trading nation
- the accumulation of out-of-date plant
- the dreadful industrial relations
- the dearth of entrepreneurship

The closure of the North British Locomotive Company in 1963 was one marker of the end, it had once employed over 7,000 men and had produced one railway locomotive every day. However, the grandest collapse was the drawn-out saga of shipbuilding on the Clyde which absorbed so much emotional and political energy in the late 1960's and early 1970's. The crash of Fairfield's shipyard in 1965 helped precipitate the belated rationalisation of the shipbuilding industry in 1968 with the creation of Upper Clyde Shipbuilders (UCS). The Clyde had previously comprised a plethora of yards, large and small, mainly niche players, for example, John Brown in liners and Yarrows in Admiralty work. Attempts to reorganise the yards into a small number of bigger yards had been too slow and had failed because of a blind refusal to compromise which meant that:

> When the Queen Elizabeth II steamed down the Firth ... it left a river which was only marginally more lively than the Styx. [Harvie, 1977, page 174.]

The business of education

George Davie [1961] has argued that in the nineteenth century the four ancient Scottish universities[2] ceased to be distinctively Scottish and became instead pale reflections of Oxford and Cambridge Universities. This was in distinct contrast to the eighteenth century when Adam Smith and Edward Gibbon could, quite correctly, compete to see who could heap more opprobrium on Oxford. The desire to emulate England resulted in the loss of a broad education steeped in metaphysics without quite reaching the standards of the English institutions. Interestingly Davie does not refer to engineering in either volume. He is concerned with competing with Oxford and Cambridge in the production of leaders when the Scottish universities were producing graduates primarily for the teaching profession, together with lawyers and ministers of religion. In many senses Davie is a classic example of Snow's arts and humanities man [Snow, 1964]. Davie was far too concerned with the loss of a particular approach, namely his own speciality of philosophy, to bother with the vital but utilitarian question of which of the Scottish, English or German models was better suited to educating Scots for life, especially economic life, in the late twentieth century, playing up a semi-mythological openness of the ancient Scottish universities. Davie dismisses German universities as dismal and pandering to the needs of an overly stratified Prussian society [1986, page 13]. Yet a question of passing historical interest is whether the adoption of the German model at the end of the last century might have significantly altered Scottish economic history and consequently Scottish political history.

In the UK there was no tradition of management education comparable with that established in Germany and the USA in the first half of this century. The Robbins Report [1963] recommended that as part of the expansion of university education there should be at least two major post-graduate business schools along North American lines. London Business School (LBS) and Manchester Business School (MBS) were established in 1965, in association with the Universities of London and Manchester respectively. In the 1960's and 1970's provision of undergraduate teaching of business and management was also expanded especially in what were then polytechnics. From the 1970's many universities began to offer MBA programmes to compete with LBS and MBS, though with the one-year course apparently preferred by British employers.

In Scotland the provision of management education goes back to the teaching of commerce courses in the inter-war years at Edinburgh University and at the Scottish College of Commerce and engineering management in the Royal College of Science and Technology. Once the Scottish College of Commerce had been merged with the Royal College of Science and Technology in 1964 to form the University of Strathclyde, it became and remains the largest provider of management education in Scotland. The Scottish Central Institutions (SCI's) were also active from the early 1960's providing Diplomas in Management Studies (DMS's) and later undergraduate courses in business.

In the mid-1960's, a Scottish business school was considered, but rejected because of the lack of demand. By 1970, the position had changed and discussions took place which rejected both a greenfield site and a version of the LBS/MBS model to be based at

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2 St Andrews (1411), Glasgow (1451), Aberdeen (1494) and Edinburgh (1583).

Strathclyde. It was decided to have a federal postgraduate school between the Universities of Edinburgh, Glasgow and Strathclyde. The Scottish Business School (SBS) was founded in 1971, later expanding to include Stirling in 1984 and Heriot-Watt in 1986. It was finally wound up in 1989 to be replaced by a much looser grouping with the important addition of professional bodies. The Scottish Business School faded away because the universities could neither learn to collaborate nor could one emerge as champion. They were condemned by their histories and their obsessive *amours propres* to senseless, unproductive competition, cloaked in a veil of collaboration. The universities fought to expand in a limited domestic market and unstable overseas market, unable to provide the quality of teaching necessary to support their courses and with an inadequate research base. Even today Scotland lacks a business school of European standing. [SED, 1987]

Communists and agitators

From the Glasgow Rent Strike in 1915, Glasgow began to acquire the label of 'Red Clydeside', though the world's first international strike had already occurred at the Singer Sewing Machine factory in Clydebank in 1911. The image stuck in the public imagination after the Forty Hour Strike in 1919 when the police broke up a demonstration of workers in George Square, where the Red Flag had been raised; barely two years after the Russian Revolution. Thereafter, the radical activities of the Independent Labour Party, an important force on the left-wing of Scottish politics, reinforced the image. Whether accurate or not, the impression held by potential English and international investors was that Scotland was an area of militant labour and hence to be avoided.

The Toothill Report commented that English industrialists saw Scotland as a place of unrest, causing them considerable reluctance to open a factory. Cameron and Reid detected strong adverse reactions in the perceptions of management-labour relations and in productivity in some, but only some, firms [1966, pages 21-22]. In truth the late 1960's and early 1970's were punctuated by many series of strikes, partly the result of changing industrial patterns and partly the Scottish share of the British disease. By comparison, the 1980's were relatively trouble free.

In 1987 the Ford Motor Company announced that it wanted to build a European factory for automotive electronic systems, an area projected to show strong growth for many years. Initially it was proposed to be built at Dundee, but a single union deal had been required. Initially this was agreed by the Amalgamated Engineering Union (AEU). However, the trades unions in Ford's long-established English car factories insisted that all the traditional trades unions be represented in the proposed Scottish plant; they were afraid that a single union deal would be forced onto them, if not immediately, then soon. In 1988, after five months of bureaucratic delay and haggling within the Trades Union Congress (TUC), Ford withdrew to build the factory in Spain. Thus Scotland lost a major factory not because of the resistance of its own trades unionists, but because of the interference of UK unions.

Government intervention

In the face of near terminal economic decline and prompted by the intermittent but spectacular electoral successes of the Scottish National Party (for example, Hamilton in

1967, Govan in 1973 and 1989), it became increasingly important to avoid economic collapse and to be seen to be trying to stimulate growth. A succession of government ministers set important political and economic aims:

- to contain emigration
- to increase employment
- to modernise the technological base
- to encourage Scottish-owned industry
- to attract inward investment

In large measure intervention took the form of encouraging foreigners to make good the deficit in the performance of Scottish and English firms. Where governments chose to rely on investment from abroad, they must deal with multinational corporations by a mixture of encouragement and regulation. In the electrical and electronic equipment industries, multinational corporations have an oligopolistic control based on proprietary technology, for example, the telephone, where in the first years of the twentieth century the best governments could achieve was to persuade AT&T and later ITT to open a local factory or to licence local production. Such problems were made worse by the increased technological dominance of the USA and by the growth in world trade in the 1950's following the General Agreement on Tariffs and Trade (GATT). Where countries seek to be at the leading edge, they have little choice but to negotiate with the multinationals. Such negotiations are made much easier where the domestic market is large or where access to a larger market is freely available. [Doz, 1986.]

In many ways industrial locations can be treated as a competitive market, with different nations, regions and cities fighting for inward investment. In recent years, 'industry rivalry' has grown with the proliferation of technopoles, science parks, free trade zones and so on. In order to attract the multinational corporations, it seems necessary to offer:

- lower costs
- tax holidays
- grants
- competitive wage rates
- skilled labour
- free factories (usually custom-built)
- executive housing
- infrastructure

To be successful and to retain the multinational corporations, it is essential to understand the individual multinational corporation and its industry, which might suggest that a niche strategy could be more rewarding than trying to be a cost-leader. Understanding your 'customer' is vital in a market where the competition is so fierce that:

> During the summer of 1978, no fewer than a dozen agencies visited a single Cupertino, California, computer manufacturer. The agencies hailed from three continents. Singapore's Economic Development Board and Taiwan's Foreign Investment Board stood out among the Asian representatives. From Europe, principal promoters included the Irish Development Authority and the Scottish Development Agency. Even North America was represented: the Puerto Rican Investments Council arrived shortly after the Massachusetts Development Board. The objectives of all these agencies were the same: to get the management of Apple Computer to consider a new plant location in their jurisdiction. The job of these contenders would not be easy. Apple's management was not actively

considering expanding to a new site. Yet three years later Apple had established two new plants: one in Ireland, the other in Singapore. [Encarnation and Wells, 1986, page 267.]

The result of such competition is to drive down the costs for the multinational corporations, with the host countries paying the price, through direct subsidy and lost tax revenues. These pressures are also liable to encourage inexperienced firms to make overseas investments before they need to and without the necessary experience.

Whether in support of 'lame ducks' or sunrise industries UK governments have spent considerable sums of money on various forms of regional assistance, for example, Regional Development Grants under the Industry Act of 1972. In many ways these have been of considerable value to Scotland. However, this expenditure cannot be seen in isolation, it is essential to compare it with expenditure in related areas, specifically on defence procurement contracts and research establishments. This changes the picture quite dramatically, if for no other reason than that defence procurement contracts are ten times the size of regional assistance (see table 1). In this light, regional assistance can be seen to be little more than a palliative.

Table 1 *Per capita expenditure by UK region in 1983*

Region	*Regional assistance*	*Defence contracts*	*Total*
South-East	0.00	220.39	220.39
South-West	2.72	174.55	177.27
North West	21.19	118.33	139.52
Scotland	43.00	80.49	123.50
Northern Ireland	70.49	45.38	115.87
East Anglia	0.00	110.37	110.37
East Midlands	4.58	90.24	94.82
North	29.66	44.64	74.30
Wales	40.46	24.74	65.20
West Midlands	0.00	53.61	53.61
Yorkshire & Humberside	7.23	28.27	35.50
UK	13.11	123.34	136.45

Source: Regional Trends, Hall *et al.* (1984) and Short (1981).

In terms of research and development establishments, the UK is singularly biased towards the South-East. The only Scottish establishments being the National Engineering Laboratory at East Kilbride (formerly the Mechanical Engineering Laboratory) and the United Kingdom Atomic Energy Authority's fast breeder reactor at Dounreay, due shortly to close.

The agency

The Scottish Development Agency (SDA or just the 'Agency') was created in 1975 by an Act of Parliament to coordinate the economic development of Scotland. The background to this was one of decaying industry with rising unemployment and industrial dereliction, while at the same time there was considerable debate about the expenditure of the oil

revenues and about the growth of oil-related industrial activity in the North-East. The idea of an integrated authority was based on the successes of the Highlands and Islands Development Board and the new town development corporations. The investment functions resembled those of the National Enterprise Board, though without its role of extending public ownership. Specifically the Agency was to:

- provide finance for business
- assist in the development of industry
- provide and manage sites and premises
- renew land

The Agency inherited the work of various government bodies and part of the work of the Scottish Council.

The circumstances at the time of its creation were that the Agency:

> ... found itself inhabiting a political environment influenced by three prominent groupings: a deeply sceptical business community, made wretched by its own lack of self-confidence; a deeply anxious political and civil service corps, made nervous by its own failures with economic performance; a deeply cynical electorate, made impatient by the evident inability of either to haul Scotland out of this mire. [Edward Cunningham, formerly Industry Director, SDA.]

To which should be added a trades union movement which was often bloody-minded and which had become enamoured of Soviet-style central planning.

Under the Thatcher Administration (1979-1990):

> The continuing rationale for the Agency and its activities must reflect the Government's general approach to intervention in the economy. In brief, the public sector should only be involved where the market alone will not produce the outcome desired by policy; and its intervention should whenever possible seek to achieve its ends by improving the working of the market and should not create dependency. Where public intervention is necessary the case for using the Agency as the instrument should be that it is likely to be more efficient than the central or local government alternatives — perhaps especially where there is felt to be a case for targeted intervention on a discretionary basis, or where the aims of a number of policies overlap. [IDS, 1987, page 6.]

The conclusions of a governmental review were that the Scottish Office was satisfied with performance over the years on balance and that [IDS, 1987, pages 11-14]:

- the Agency had a high standing among the business community and financial institutions
- the private sector could not fill the gap if the Agency were removed
- the Agency has succeeded in bringing together many different parties to achieve economic and environmental regeneration
- given the continuing restructuring of the Scottish economy the need for the Agency continues
- there was no need for change in statutory powers, purposes and functions
- there was a need to revise the structure to improve its fit with policies and objectives

In the scramble for inward investment in the late 1970's, the activities of the Scottish Office, the Scottish Council (Development and Industry), SDA, new town development corporations, regional and district councils were often overlapping:

> Failure to coordinate these activities may cause not simply confusion but something bordering on contempt. [Committee on Scottish Affairs, 1980, page 12.]

The response of the government was to create Locate in Scotland (LIS) in April 1981 as a joint venture between the SDA and the Industry Department for Scotland (IDS), part of the Scottish Office. It opened offices in London, Brussels, Chicago, Stamford, Houston and San Francisco to help it identify potential inward investors. LIS is supposed to be a client-orientated organisation and thus can be assessed, at least in part, in terms of customer satisfaction. It was to be a fast response, one-stop shop for:

- grants
- loans
- advice
- access to experience

One of the most highly publicised moves involving LIS came in October 1989 in response to the announcement by Motorola that it was interested in establishing in Europe a plant to build cellular telephone equipment. Within forty-eight hours a Locate in Scotland team — comprised of Edward Frizzell and Martin Togneri from the SDA and James Scott from the Industry Department Scotland — was in the USA with a detailed proposal for the factory. Later they were able to organise visits for Motorola staff to potential sites and to other firms operating in Scotland. An undertaking was provided to expand a local technical college to train the necessary skilled technicians. The factory was opened at Easter Inch in West Lothian in 1991, joining Motorola's semiconductor factory at East Kilbride.

The Agency and Locate in Scotland seem to have operated on the 'panther principle' — sitting in a tree waiting for something nourishing to pass by on which they could jump. In the 1970's there was a switch in the direction of foreign direct investment from US-based firms towards locations in other parts of the European Community, in particular to West Germany. It seems clear that Scotland was slow in emphasising the need for companies to have R&D.

A branch plant economy

By the late 1970's an economy had emerged and, in part, had been designed, which was largely outwith the control of Scotland and the Scots. It was dependent on the decisions of non-Scottish managers and overseas investors — sometimes their whims. When faced with economic problems, multinational enterprises based in England and the USA almost invariably decided that it was easier to close their factories in Scotland, rather than those at home:

> Where the Scottish operations have suffered disproportionately, the reasons given normally related to low productivity, overmanning, restrictive practices or poor labour relations. Within a multinational system comparative plant performance may be closely monitored, and poor performers are highly vulnerable. If a plant is fairly small, does not represent a unique source for a particular product or component or has no research and development unit, then once again closure is a strong possibility when multinationals are taking restructuring or rationalisation decisions. [Hood and Young, 1982, page 151.]

Although factory closures were a well-known weakness of 'location' and 'regional' development, their effect when it occurred was not lessened by the intellectual awareness of its likelihood, indeed its well-nigh inevitability. Scotland lost jobs at Caterpillar Tractors, Goodyear Tyre, Massey-Ferguson Tractors, Monsanto Chemicals, Singer Sewing Machines and in the closure of the Linwood car plant [Hood, 1982].

Figure 2 shows the number of people employed in overseas-owned plants in Scotland since the 1950's. From the mid-1970's it is clear that the number of jobs was declining, though the percentage of the total manufacturing workforce was rising, indicating a rather better performance in the overseas-owned sector than in the UK-owned sector.

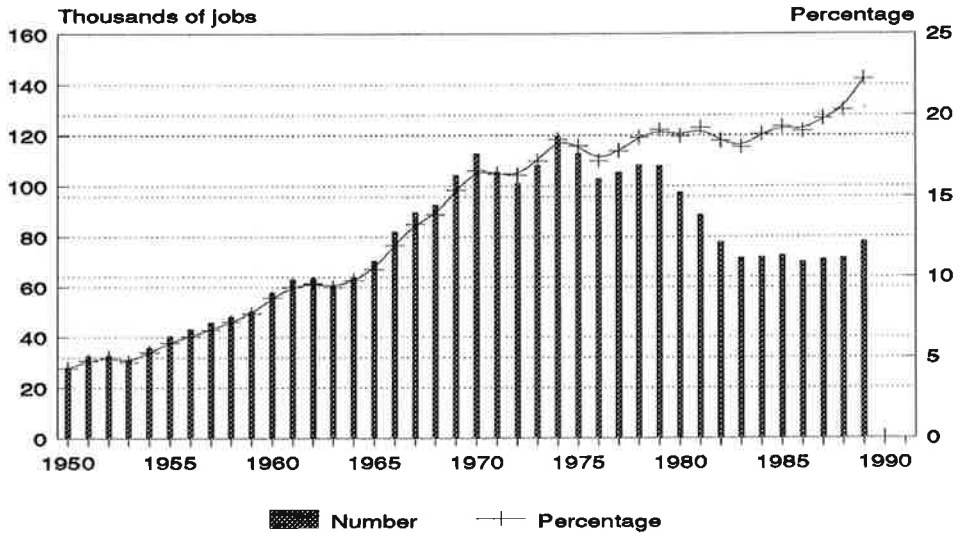

Figure 2 *Employment in overseas-owned plants*
(Data source: IDS, A3.3, 1990, page 27.)

The feeling of Scottish economic helplessness was reinforced by the continuing loss of control of leading Scottish firms through mergers and acquisitions, of which the most dramatic was the acquisition by Guinness of Distillers (see table 2). However, the 'Scottish Card' could sometimes be played effectively, for example, blocking the bids for the Royal Bank of Scotland from the Hong Kong and Shanghai Bank and the Standard Chartered Bank in 1982.

Table 2 *Acquisitions and mergers*

Target	*Acquirer*	*Nationality*
Apollo Blinds	Laura Ashley	England
Arthur Bell	Guinness	England
BNOC	BP	England
Coats Paton	Viyella	England
House of Fraser	Al Fayed Brothers	Egypt/England
Distillers	Guinness	England
Scottish and Newcastle Brewers	Elders	Australia
Yarrows	Trafalgar House	England

Source: *Financial Times.*

A leading French industrialist has expressed scepticism at the British approach of seeking out inward investment:

> I think the British are wrong, completely wrong. They believe that an infusion of Japanese capital and management through transplants of factories will revitalize British industry. I don't believe a word of it. A few thousand jobs in Wales or Scotland are not the issue. The issue is the repair of the national tissue of technological and managerial competence. [Alain Gomez, Chairman, Thomson]

This raises important questions over the extent to which technologies and management technqieus are likely to be adopted in Scotland.

The Scottish electronics scheme

In the late 1940's the Scottish Council recognised that Scotland had missed out on the motor car and aircraft industries and that something had to be done if this was not be repeated for electronics, which was seen to be even more important. The Ministry of Supply and the Admiralty played an influential role in the UK electronics industry and in other areas of advanced engineering through development contracts. The Scottish Council argued that while the government was spending money through the Board of Trade encouraging firms to locate in Scotland, the Ministry of Supply and the Admiralty were not helping by placing almost all of their contracts in the South-East and South-West of England. Therefore, in 1948 the Scottish Council proposed to the Secretary of State for Scotland that Ferranti Ltd be used as a leader in contracts allowing staff from other firms to be trained in design by Ferranti. HMG was willing to give contracts to firms in Scotland, if the Scottish Council could identify suitable candidates. After due consideration HMG wanted efficient teams of "six or seven design engineers", which although common in the South-East were much less frequent in Scotland. It cannot be a coincidence that the then Secretary of State, Arthur Woodburn, had been promoted there from the Ministry of Supply.

A joint venture was established with Ferranti Ltd, the Ministry of Supply and the Admiralty in May 1951 in order to build up the Scottish electronics industry. Initial contact for firms was through the Scottish Council who arranged for potential participants to visit Ferranti's laboratories and a government research establishment. If the firm was still interested discussions followed with the management of Ferranti, thereafter the defence ministries were approached in search of a suitable joint contract. The design teams were to work initially with Ferranti, later moving to their own premises. Some arrangements were made by Ferranti subcontracting work on their own initiative from their own contracts, apparently driven by John Toothill, Managing Director of Ferranti in Scotland. Ferranti hoped to gain insights into the applications of electronics in the engineering industry. For the other firms a design contract would allow them to hire a design team. [Burns and Stalker, 1961, pages 43-51.]

The intention was not to build up a radio and television industry, rather:

> The objective was then, as it remained, the intrusion of electronics technology into the engineering industry so as to create new applications — most of them as yet unrealized — which would become visible to specialist engineering firms as they became familiar with the new technologies. [Burns and Stalker, 1961, page 49.]

While still in the planning stage, the increased defence requirements of the Korean and Cold Wars led to an increase in the proposed size of the laboratory. Then in 1951 the government imposed a ban on funding for the construction of all new buildings as a result of financial and economic problems causing a delay in building the Ferranti Laboratory at

Crewe Toll until 1953. The Laboratory was finally opened in October 1954 by HRH the Duke of Edinburgh. The project again ran into difficulties in the 1957 with the defence cuts in the aftermath of the Suez Crisis, when the government severely reduced expenditure on new defence contracts. At the same time the viability of the idea had changed since 1949, because the products being designed by Ferranti were now much more complex, it was more important to have in-house control of the design. Thus the project foundered in part because the government saw the growth in Scotland of multinational corporations in the electronics sector and because defence was now contracting:

> The scheme was launched as a pump-priming operation and I think we must admit that the defence policy compels us to reconsider our attitude towards it rather earlier than was perhaps intended at the outset. Bearing in mind that the scheme has already achieved some considerable measure of success and that by other routes the electronics industry is beginning to establish itself in Scotland, I do not think that the Ministry of Supply need take abnormal measures and positively direct work to Group firms; to do so we should have not only to justify the real but indeterminate increase in the cost to the Defence Budget of the relative inefficiency of the fledgling firms, but also to counter criticism from established concerns that we are favouring relatively inefficient Scottish firms at the expense of relatively efficient firms elsewhere. [Aubrey Jones to John Maclay, 1.viii.1957, SRO/SEP4/2082.]

Although phrased impolitically, this letter explains why the scheme closed.

The six firms involved in the Electronics Scheme had workforces ranging from 150 to 1,500 and were all seen as sound businesses. Some firms were already in difficulties with obsolete products or were operating in markets which were collapsing:

> With the advantage of hindsight it can be suggested that the attempt to impose a dynamic technology upon organisations adapted to a stable or declining market environment and firmly rooted in a *regional* engineering complex was insufficient. The types of organisation necessary to translate technical advances into successful products in a more dynamic, diffuse and *international* market context were not created to support the technology transfers achieved by the Scottish Council-Ministry of Supply Scheme. [McDermott, 1979, page 293.]

Being at a great distance from the UK centres of electronic excellence these firms were not advanced and were sometimes quite backward in their use of electronics:

> It made directors extremely cautious about commitments, rendered them over-dependent on the goodwill of defence ministries, and made it harder for them to develop effective relationships with the markets already receptive to electronic devices. [Burns and Stalker, 1961, page 70.]

Despite entering the Electronics Scheme some participants kept their design teams isolated, working only on their defence contracts and not on commercial work and also failed to match sales efforts to their work in R&D. There was little, if any, useful interaction with operational divisions of the firms concerned.

Cultural factors were clearly part of the story. Before the war the companies were small and operated without research; where design teams existed they were often distinct units poorly integrated into overall production. Fundamental problems existed in their planing functions:

> More important than the explicitly stated reasons seems to be the fact that the middle-distance future was obscured by extreme preoccupation with the short-term future. Firms in the radio and television business are geared to annual cycles of new designs-production-sales, each successive activity rising to a peak in early spring, the summer and autumn. [Burns and Stalker, 1961, page 66.]

Incomers

In looking overseas, the initial problem was how to attract multinational corporations to a remote part of the world and one shrouded in *clichés*:

> The Committee has been left in no doubt that there is very often a need to disabuse a client of his probably thoughtless (but equally likely deeply-ingrained) preconceptions about Scotland. He may see it as some kind of Brigadoon[3] never-never land, or a damp depressing expanse of grey tenements and high unemployment. [Committee on Scottish Affairs, 1980, page 15.]

Nonetheless, there can be little doubt about the superficial success of the inward investment policy, with table 3 showing some of the firms which opened plants in Scotland.

Table 3 *Branch plants opened in Scotland*

Company	*Location*	*Date*
Remington-Rand	Hillington	1937
Ferranti	Edinburgh	1943
NCR	Dundee	1946
Timex	Dundee	1946
Honeywell	Blantyre	1948
IBM	Greenock	1951
Hughes Microelectronics	Glenrothes	1960
Hewlett-Packard	Queensferry	1964
General Instrument	Glenrothes	1968
Motorola	East Kilbride	1969
National Semiconductor	Greenock	1969
Burroughs	Livingston	1971
DEC	Ayr	1976
NEC	Livingston	1980
Sun Microsystems	Livingston	1984
Wang Laboratories	Stirling	1984
Compaq Computer	Erskine	1987
Oki	Cumbernauld	1987
Delta	Inchinan	1990
Seiko	Livingston	1990
Fuji Electric	East Kilbride	1992
Canon	East Kilbride	1993

Sources: various.

The reasons why foreigners came to Scotland to build factories would appear to have been:

- English language
- low labour costs
- ancestral and cultural connections

[3] Brigadoon was a Broadway musical in which the image of Scotland was twee and cloyingly sentimental. Two Americans find a ghost village in Scotland which awakens one day every one hundred years in which the actors were swathed in tartan and the actresses bedecked in heather. It was first produced in 1947, then turned into a film in 1954 by Alan Jay Lerner, the author, and director Vincente Minelli. While the stage version had been seen as whimsical and charming, the New York Times found that the film was as "pretty weak synthetic scotch", despite the talents of Cyd Charisse and Gene Kelly.

- scientific and engineering tradition
- access to markets
- governmental encouragement and support

The Scottish scientific and engineering tradition may, in practice, have been largely or wholly irrelevant, but an image was still there from the era of 'Clydebuilt' with the liner, the Queen Mary anchored off California as a reminder. The idea of the Scot as engineer was revived in the television series and films of *Star Trek* where the chief engineer on the USS Enterprise was 'Scotty' complete, on occasion, with kilt and bagpipes.

A factory in Scotland could open the way to inclusion in preferential purchasing for UK defence contracts and more generally to markets in the UK, the British Empire, the Commonwealth, the European Free Trade Area and, after 1971, the European Community. However, access to the public sector in the UK markets was problematic, with strong pressure to buy British, primarily to support ICL.

The UK government encouraged almost anybody with a plausible proposal to come to Scotland as an expedient to revive the Scottish economy, offering tax relief, automatic grants, selective financial assistance and so on. By comparison, the French government has been at best neutral and often anti-American, especially in the defence sector. The Germans believed, correctly, that they could do without inward investment. Spain, Portugal and Greece were late entrants to the European Community and so only recently offered access to the Common Market, they also lacked the more advanced technical skills among their workforces. Now the competition includes the post-communist countries of central and eastern Europe.

Figure 3 shows the breakdown of employment in the electronics and IT industries by product grouping, which has been relatively stable for the last decade.

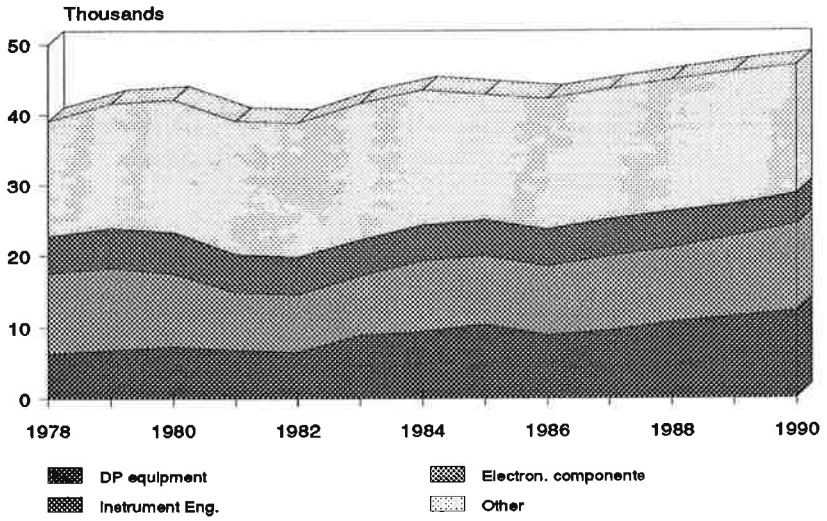

Figure 3 *Employment by industry grouping in the IT sector* (Data source: IDS.)

Figure 4 shows the changing composition of ownership of plants in Scotland. It reflects the decline of the European Community, excluding the UK, and the growth of employment by firms from the rest of the world, principally Japan.

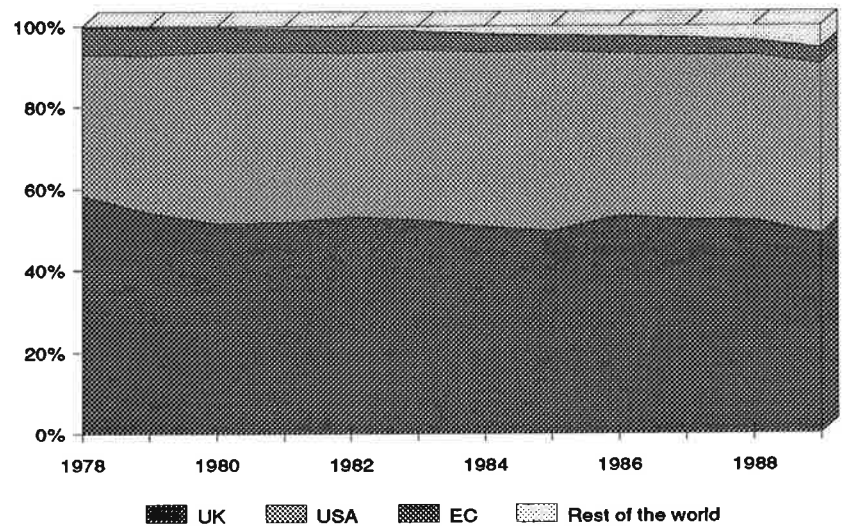

Figure 4 *Electronics employment by country of ownership*
(Data source: IDS, C1.4, 1991, page 4.)

The first companies to reverse the historic relationship between Scotland and North America, by making a direct investment in Scotland, were Uniroyal in 1856 and Singers in 1867. The Singer Sewing Machine Company opened in 1867 and by 1900 the factory was producing 13,000 machines per week. However, with economic changes, Singer's Clydebank factory closed in the late 1970's and ownership of Singers has now passed to Hong Kong. At the end of the Second World War, the number of US-based firms in Scotland was still only six but rose rapidly. For example, National Cash Registers (NCR) came to Dundee and Honeywell opened in Blantyre. Most of the factories of the late 1940's and 1950's were light industrial activities, usually relying heavily on low cost unskilled or semi-skilled female workers.

National Cash Register

National Cash Registers (NCR) was created in 1884 by John Patterson when he bought the National Manufacturing Company. One of Patterson's most lasting legacies to the computer business was to train a young salesman, Tom Watson who went on to found IBM and to copy the sales techniques which Patterson had developed for weighing machines and cash registers. Based in Dayton, Ohio, NCR rapidly developed its business across the USA, achieving ninety-five percent market share, and moved overseas, having ten foreign operation before the First World War. In the 1920's NCR extended its range of products to include adding machines and accounting machines, making it a direct competitor of IBM in the punched card business.

In NCR 1953 bought Computer Research Corporation (CRC), a Northrop Corporation spin-off, which manufactured small computers for the military. These

machines were developed into small business systems and a larger system was developed with General Electric. NCR also re-badged a Control Data Corporation minicomputer in the early 1960's. These were all small machines aimed to two sectors, banking and retailing.

In 1946, NCR opened its first factory in Dundee, chosen for low operating costs, especially labour. The factory produced cash registers and accounting machines for the UK market by assembling parts imported from the USA. NCR expanded its Dundee operations by creating the capacity to manufacture the parts which it had initially imported and it also increased its procurement of local parts. By the late 1960's, the Dundee operation was largely self-sufficient. At its peak, NCR employed 6,500 people and operated 120,000 m^2 of space in nine factories, of which eight were leased from the government.

The peak of NCR's Dundee operations came in 1969-70, just as the UK was switching from £sd to £p, requiring vast numbers of new adding machines and cash registers and the conversion of existing equipment. Up to this time there were few problems, labour relations were good and staff turnover was low. By comparison with the other European plants, Dundee was large and clearly of considerable importance to NCR, even if R&D was located in Dayton.

NCR was continuing to manufacture electro-mechanical machines which had come under considerable attack from electronic machines. Transistorised calculators from Texas Instruments, Wang Laboratories and a number of Japanese manufacturers cut into NCR's traditional market. Computers were proving an expensive business to be in, especially in responding to the continuing success of IBM and, to a lesser extent, DEC. Data processing generated revenue but little profit.

In the late 1970's, NCR appointed a new CEO from NCR Japan, William Anderson, a second generation American of Scottish descent, who sought to focus the business on data processing systems and terminals, primarily in banking and retailing. The new priorities were to decentralise manufacturing to plants of around one thousand people and to reorganise marketing.

In the manufacture of electro-mechanical systems it was feasible to use vertical integration (NCR Dundee even manufacturing its own screws) though with electronics this was impractical. The change meant that costs were turned upside down, from labour being seventy-five percent of finished systems, purchases of components and sub-assemblies rose to 60-80 percent. NCR invested in semiconductor manufacturing capacity and in 1980 acquired Applied Digital Data Systems, a manufacturer of computer terminals. Product lifespan collapsed, requiring enormous efforts in the design of new products and much greater flexibility in manufacturing, while the relationship with customers had to switch from selling and maintenance to quite sophisticated marketing. As old products were phased out, so the worldwide workforce was cut, from 103,000 to 64,000. NCR closed four European factories at Berlin and Giessen in Germany and at Burlach (Switzerland) and Massy (France) in order to concentrate at slimmed-down plants at Augsburg and Dundee. A long trail of redundancy announcements began in 1971. NCR conscientiously sought to retrain staff for the new jobs in the plant, even if the changes were enormous. Only in 1978 had the Dundee plant become fully orientated to electronics.

The organisational structure of NCR was also changed. From 1977, the Dundee General Manager reported to the US-based vice president for the Computer and Communications Systems Division, as part of a global restructuring of manufacturing. NCR was creating smaller plants with a group of related products for which the plant would hold a 'charter'. In the late 1970's, Dundee was the supplier of the 8200 and 8500 Criterion mainframe computers to Europe, Middle East and Africa and a second source to the plants in the USA. Dundee also held the sole charter for banking terminals, initially producing a US-designed model, but with R&D funding to develop it.

Dundee thus became the centre of NCR's global business in Automatic Teller Machines (ATM's). Today, headed by Jim Adamson, a Scot headhunted from ITT, and with a staff of some fifteen hundred. NCR Dundee markets, designs and manufactures its own products; a business currently worth US$ 600 million per annum. Almost 400 of the staff are engaged in R&D. In 1990 it won the award for Britain's Best Factory. Management communicates with the workforce directly, as well as through the trades unions. There has been a major campaign to promote continuing education 'Education for all' to encourage staff to undertake part-time degrees and diplomas.

The acquisition of NCR in 1991 by American Telephone and Telegraph (AT&T) raises questions concerning whether the ATM business will be seen as a core activity to be retained or whether it should be disposed of. There are also questions of the style of the management and whether the same level of autonomy will continue.

International Business Machines

Following the termination in 1949 of a licensing agreement between IBM and British Tabulating Machines (later a part of ICT and subsequently ICL) IBM began its own direct operations in the UK [Campbell-Kelly, 1990]. The choice of IBM Greenock was influenced by the acquaintance of IBM's CEO, Tom Watson Snr, with Hector McNeil, the local MP, who had served at the United Nations. McNeil had visited IBM Endicott and had told Watson that he had a site for him in Scotland should be ever wish a factory in the UK. Watson, who was of Scottish descent, personally selected the site in what became known as Spango Valley on a visit to Greenock in 1950. Tom Watson Snr specifically rejected existing industrial sites which could be converted, demanding a greenfield site to give a pleasant aspect to the plant and to allow space for recreational activities, including a golf course and a swimming pool. The choice of the site was poorly received by the local planners, who wanted to redevelop existing industrial sites:

> It is going over old ground but it must be stated here again that the Kip Valley is not, in my opinion, the best place in which to put new industry for Greenock. If, however, as a matter of policy ... [Renfrew County Council Planning Officer.]

Watson's requirement for a greenfield site and McNeil's desire for a political success won the day against the planning officer.

As a temporary measure in 1950, IBM took over a former torpedo factory of 2,000 square feet in Battery Park, Greenock, with the first typewriter produced in October of that year. In 1954, IBM finally moved a short distance to a specially built factory on its present site in Spango Valley, which it bought from the Scottish Industrial Estates Corporation in 1959.

Initially, the factory manufactured a wide range of equipment, including typewriters and accounting machines, mainly for the UK market. Production of electronic computers began in 1956 and by the late 1950's, IBM was manufacturing: computers, accounting machines, punched card equipment and electric typewriters.

In 1964, IBM began to manufacture ancillary equipment (keyboards and terminals) for the new System/360. This meant a very difficult transition from electromechanical technology to electronics. In common with Honeywell, IBM was affected by British protectionism and influenced by having plants in other European countries. Manufacturing in Scotland only made sense when the domestic market was profitable. The decision to manufacture the System/360 in 1964 was, therefore, a challenge to British computer manufacturers.

With the reorganisation of IBM in the 1970's, Greenock became part of the Systems and Communications Division, manufacturing keyboards, terminals, communications systems and so on. Although the Greenock plant does not have an R&D function — UK R&D is based at Winchester — it appears to have been highly rated within IBM Europe and in January 1983 was chosen to assemble the IBM Personal Computer with UK government support of £2.5 million. This was a key decision, since the IBM PC was seen to have a large and growing market and the choice of location was highly contested within IBM Europe. The Greenock Plant is one of the most advanced electronics plants in the world, including a robot-controlled assembly and despatch unit.

IBM puts considerable emphasis on training and the education of its workforce. Managers are expected to have five days training a year and other staff from eight to ten days. In the twelve months from March 1990 to March 1991, IBM staff at Greenock received 9,000 person days of training. IBM operates an Open Entry College to allow staff to pursue degrees and diplomas in conjunction with Strathclyde, Paisley and Napier Universities. [Scottish Business Insider, September 1991.]

IBM is Scotland's largest single exporter and IBM UK has twice been awarded the UK Queen's Award for Export Achievement. However, the export figures need to be treated with caution, since IBM is also a large scale importer of components. Of its supplies, valued at approximately £780 millions, 30% are purchased in Scotland. Figure 5 shows the breakdown by component category.

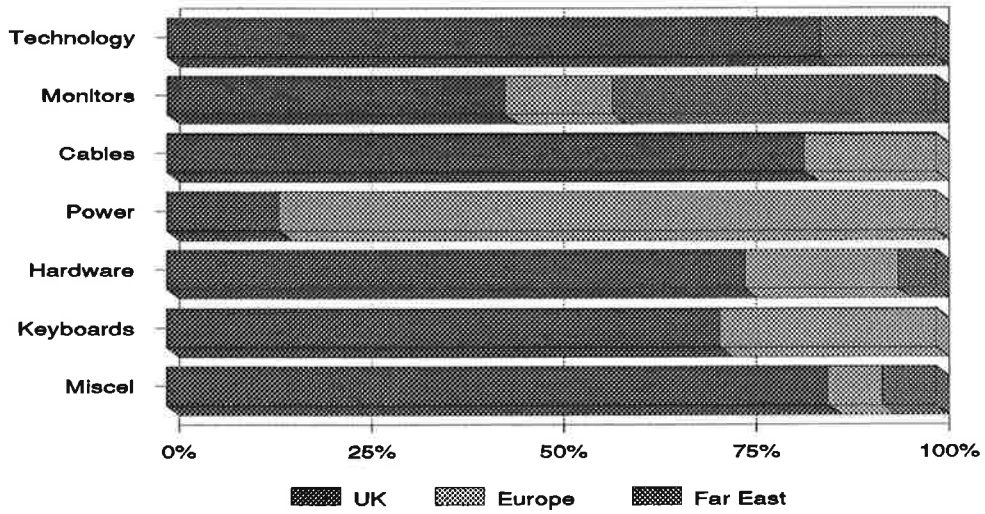

Figure 5 *Component sourcing at IBM by value in 1990*
(Source: Scottish Business Insider, September, 1991.)

The 1990's have been a difficult time for IBM with competition in all sectors eroding its profitability. In response to this the IBM board launched a major restructuring in 1991, in the hope that by devolving responsibility to eight divisions the corporation could be made more responsive to customers and hence more profitable. The success of this move has yet to be seen.

Here today, gone tomorrow — Wang Laboratories

When Wang Laboratories first came to Europe they chose Limerick in the Republic of Ireland, only later did they come to Stirling (both were university campuses). The apparent reason for the move to Scotland was growing demand in Europe combined with the belief by the founder, Dr An Wang, that plants should not exceed 200 persons if they were to be properly managed. The funding from the government was an attraction to come to Stirling, though not being in a Development Area, this was less than it could have been. There was a less clearly stated desire to improve Wang's share of the public sector market in the UK, which required a manufacturing operation in the UK. Once the factory was announced, Wang was awarded the last of the government's Office Automation Pilot Projects, a fully operational demonstrator system at the National Coal Board (now British Coal). Wang Labs claimed the link to the University of Stirling would be important. However, it was limited to the funding of a research fellow. In order to encourage Wang Laboratories, Central Regional Council funded a chair in information technology, by 'topping up' the salary of a lecturer.

The closure of the Stirling factory in 1989 was no very great surprise to observers in the industry. That Wang Laboratories was later and briefly 'saved' by a joint venture with IBM can be taken as little comfort, IBM wanted Wang's customer base and its software capability; a factory in Stirling for the manufacture of personal computers was not required. The manufacture of personal computers is a relatively unsophisticated activity, with over one hundred and fifty firms worldwide making and selling clones of the IBM

Personal Computer and PS/2. Where skill is required is in the development and introduction of new models and in management of the distribution channels.

Wang Laboratories had been founded in 1954 and controlled by Dr An Wang, who had jumped with considerable success from one area of business to another; from computer memory to electronic calculators and on to minicomputers and word processing systems [Wang, 1986]. The closure of the Stirling plant in 1989 was due to a failure the business strategy. It had allowed itself to become embroiled in the fiercely competitive PC market and had become, albeit inadvertently, 'Just Another PC' manufacturer.

In 1992 Wang Laboratories filed for 'Chapter 11'[4] protection from its creditors in the US courts and seems doomed for liquidation.

Disc crash at Rodime

Rodime was one of those rarities, a Scottish spin-off. It was founded in 1980 by two Scottish and two American engineers from Burroughs (now part of Unisys), led by Dr Leonard Brownlow.

In October 1991, Rodime called in the receivers for their operations in Glenrothes and Singapore and filed for 'Chapter 11' bankruptcy protection for its plant in Boca Raton, Florida, USA. This was despite a rescue in 1989 with the introduction of new management from the USA and an injection of cash. Rodime was not being paid royalties for its hard disc patents, an issue which it is still addressing, even though it will no longer manufacture disc drives; in effect, it will remain in the legal business.

Rodime had initially produced 5.25 inch hard discs and was the first company to develop the smaller 3.5 inch hard disc drive, found in most current personal computers. Manufacturing at Glenrothes was expanded first to Singapore and then to Florida. The design and manufacture of disc drives is, like so much of the IT industry, a cut-throat business, where new products must be brought to market as soon as humanly possible. The cutting edge of the industry has moved on from 3.5 inch drives to 2.5 inch and 1 inch drives for use in laptop and portable PC's. Moreover, the well-known difficulties faced in the personal computer industry with the downturn in demand in 1991 led to a collapse in disc drive prices.

The key question is why Rodime failed. It seems to have been too far from its market, the PC manufacturers. Moreover, there were too many rival start-ups, there was enormous competitive pressure for business and the technological pace was fast and accelerating.

Spider Systems Limited

Spider Systems arose from the decision of ICL to close its Dalkeith operations as part of a program of rationalisation in 1983. One of the spin-offs of this closure was Spider Systems, a networking software firm founded by Peter Palmer and four others. The beginnings were modest:

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4 Chapter 11 refers to the filing of protection from creditors with a court in the USA. Usually this is to allow for reconstruction of the company.

> We started out as a subcontractor for other manufacturers, mainly in the field of local area networks, with plans to develop our own systems as the opportunity arose ... Our expansion was made possible through the growth of Local Area Networks using the Ethernet standard. Having international standards to work to allows smaller companies to develop innovative products, which can be used in virtually any computer system. [Martin Ritchie.]

Today, Spider Systems is a world class supplier of Unix networking software to

- original equipment manufacturers
- value-added resellers
- systems integrators
- leasing firms

Spider's customers include: Hewlett-Packard, Microsoft and Unisys. The products supplied include implementations of a number of popular telecommunications protocols, such as, TCP/IP and Unix Streams. In working with OEM's, Spider builds long-term relationships with 10-15 year licensing agreements. As these companies bring hew hardware on-stream, Spider with the supplier to 'port' the networking software onto the new systems, either in Edinburgh or at the site of the customer.

Spider's good performance has been is due to its considerable success in developing the right products, managed despite very little contact with end users. In a market such as Unix communications, it is far from obvious which products will succeed and which fail.

Conclusion

A case against the introduction of multinational corporations into local economies can be made, in that they distort a national economy [Dunning, 1970, pages 270-290]:

- drawing on local capital to the disadvantage of indigenous firms and perhaps straining local capital markets
- siphoning off technical and managerial expertise
- reducing the ability of, in this case, Scots to plan and control their economy

The benefits of inward investment, such as they are, have been short term and that time period is getting briefer as product life-cycles contract. Nonetheless the creation of direct jobs in the electronics and IT sector has been very beneficial to the Scottish economy. Important choices exist in attracting industry, if it is basic assembly which in the past would generate large numbers of jobs, mainly for women, it would be subject to closure at relatively short notice and is unlikely to have significant economic multiplier effects. More sophisticated operations will require fewer but more skilled labour, will purchase more components and sub-assemblies, recruit graduates and be more likely to generate spin-offs.

The case against multinationals is not as strong as some critics would claim. The closures are less often the result of Machiavellian scheming than the result of a failure of strategy or of corporate vision.

Scottish factories remain on the periphery of the operations of the multinational and always have been and are today being hit by recession; carrying all the variability in demand.

In retrospect, it is clear that the 'failure' of inward investment in the electronics and IT sectors lay in not stating clearly what the 'critical mass' was to be and then systematically developing it and, in particular, what was required of the indigenous sector. The atomistic

Californian model of Silicon Valley was inappropriate; a great diversity of unrelated firms in Scotland would never permit the interactions necessary for the mass to 'go critical'. This was made worse by the firms being scattered across Scotland, mainly in new towns. Although this was a plausible policy both for the SDA and the firms themselves, it was one which reduced the likelihood of interaction. The firms wanted a safe and secure labour supply, while the SDA wanted good news for each of the new towns, encouraging geographical fragmentation.

There is no credible independent technology remaining in Scotland. It is all owned by foreigners or, what is seen to be worse, by the English. The solutions might include:

- technological incubators
- subsidised consultancy for companies during formation
- attract inward investment with integrated R&D
- attract back to Scotland expatriates working in the US electronics and IT industries
- improve links between universities and companies;
- increase output of PhDs in software and electrical engineering
- improve longer term investment
- contain emigration of graduates, especially in electronic engineering and computer science
- manage the transition of the defence sector

The overall status of the sector is shown in table 4.

Table 4 *Summary of Scottish electronics and IT industries*

	Scotland	*Other UK*	*Other EC*	*USA*	*Japan*
Semiconductors	Ferranti niche	limited	none	Strong & NEC	suppliers
Computers	none	defence only	Groupe Bull	PC's & workstations	Apricot & OWL
Consumer electronics	none	weak	none	none	strong
Telecomms	none	none	none	Motorola	none
Components	limited	limited	limited	limited	limited
Software	many but small	limited	limited	none	none

The effects of hyper-active venture capitalism could be very worrying for Scotland. Locate in Scotland (LIS) operates in California to encourage companies to build factories in Scotland, in effect, joining in the 'feeding frenzy', concerned to get some new industry, by offering relatively low cost labour (in European terms) and incentives up to and including investment capital, before they are snapped up by another country. The future of the Scottish economy should not rely on games of chance being played in California.

Since the naming of Silicon Glen in the early 1980's the electronics and information technology industries it has been a period of quite dramatic and often traumatic change.

The global electronics and IT industries are in turmoil; firms which were once bitter rivals are now in joint ventures, there has been through a flurry of mergers and acquisitions — often fiercely contested — while programmes of rationalisation have led to large numbers of redundancies. In Scotland, companies have been laying off staff and closing factories (see table 5). There has also been a loss of control of small and potentially successful Scottish firms, for example, through the acquisition of Office Workstations Limited (OWL) by Mitsubishi (Japan) and of Compugraphics by Laporte Industries (France).

Table 5 *Some recent closures and lay-offs*

Company	*Ownership*	*Event*	*Jobs*	*Date*
GPT	England	Plant closure	200	December 1992
Compaq Computer	USA	Redundancies	150	November 1991
Unisys *	USA	Plant closure	868	October 1991
Conner Peripherals	USA	Redundancies	95	October 1991
GEC Ferranti	England	Plant closure	657	August 1991
Seagate	USA	Plant closure	220	1991
Rodime	Scotland	Plant closure	200	March 1991
Hewlett Packard +	USA	Plant closure	124	March 1990
Wang Laboratories	USA	Plant closure	239	September 1989

Sources: *Financial Times*, *The Herald* and *The Scotsman.*
Notes: * formerly Burroughs
+ formerly Apollo Workstations

The Scottish Development Agency (1975-1991) and Locate in Scotland (1981-) have been the institutions through which government has operated to supplement and encourage the market. The Agency has cleared up the derelict industrial landscape, built new factories and encouraged small businesses, while LIS has sought out potential foreign investors. For political reasons, the Agency has recently been merged with the Training Agency and given a new form — a central Scottish Enterprise and thirteen Local Enterprise Companies — intended to achieve greater local involvement and improved local responsiveness. This new form remains untested but is already being subjected to criticism. In any event the continuation of past policies and practices seems unlikely to yield any significant results.

The early 1990's have seen a major change in the business climate for electronics and IT vendors; shifts from mainframe computers to personal workstations and from manufacturing to added-value services, have combined with a major recession. These have had significant effects on the Scottish electronics and IT industries; plants have been closed by multinational corporations, while locally owned firms have been bought over or have gone into liquidation. The long desired, much touted but ill-defined 'critical mass' has not been achieved and seems ever less likely.

In recent years there has been a decline in the flow into Scotland of US-based inward investment, related to the difficulties faced by US-based multinational corporations in the increasingly competitive world markets and the fight from other countries and regions to attract inward investments. The Japanese have taken the place of the Americans as

principal new investors in Scotland. As a long-term strategy, the 'branch economy' has performed poorly and has been difficult to sustain.

The individual factories are isolated from one another and they buy little from local suppliers. Spin-offs have been few and most have failed. Scottish ventures are seen to lack in the qualities deemed essential for significant success, i.e. they have:

- too little entrepreneurial spirit
- limited business experience
- too little technical experience

Links between universities and industry have been inadequate. Too few brilliant students study engineering and computing and those that do lack the broader business skills and role models of their counterparts in the USA. In California the governmental support mechanisms are much less than in Scotland, but the culture is far more positive towards entrepreneurship and more forgiving of failure; the rewards are also greater. Indeed one of the great successes of Silicon Valley has been its ability to generate and propagate new businesses. Many of the better students in Scottish universities, especially doctoral students are not Scottish and usually return overseas on completing their studies.

The success of economies such as Korea and Japan have been achieved by quite different means from those in Silicon Valley. Alliances have been forged between government and industry, sharing the costs of research and development, protecting domestic markets and targeting export markets. Inward investment played a modest role in the early stages, but once the pump was primed the indigenous conglomerates quickly took over.

Given the fierce competitive struggles in the industry and the increasingly desperate struggle for inward investment it seems unlikely that Scotland can continue to draw in investments. A massive effort in the production of electronic engineers and computer scientists at all levels, especially PhD and EngD, might help attract a higher level of activity and increase the likelihood of spin-offs. The supply of components and sub-assemblies could be increased. There is a need for specific targeting and collaboration with companies — an acceptable risk, since it is the last chance. It would also be worthwhile trying to encourage some of the successful ex-patriate managers and engineers to return to Scotland, partly for the economic effect this might have and partly as role models. The constraints of the existing structures must be overcome if this strategy is to succeed.

The author

Ewan Sutherland is based at the Centre for Informatics, Saint David's University College, University of Wales, Lampeter, Wales, SA48 7ED. Electronic mail Ewan@uk.ac.lampeter. Telephone +44 570 422351. Facsimile +44 570423423.

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