# The Implications of Option Pricing Theory on United Kingdom Development Policy

Thesis

UNRESTRICTED

# The implications of option pricing theory on United Kingdom development policy: Submission for Ph.D in Development Studies

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# The Implications of Option Pricing Theory on United Kingdom Development Policy: Thesis Abstract

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Investment policy makers have consistently sought to promote inward investment through investment incentives of various kinds (e.g. capital grants, depreciation allowances). In applying these instruments, governments seek to influence companies as they apply a traditional investment decision making approach known as Net Present Value (NPV) analysis. Each of the government investment incentives influences some aspect of the NPV calculation.

Relatively recent research by McDonald Siegel (1986) has shown that for certain classes of investments, the NPV approach is inaccurate, often by a factor of two or more. This is because the NPV approach neglects the value of the option gained when a company chooses not to invest; by waiting a year or more, a company gains insight into macroeconomic and industry factors. If a company chooses to invest today, it must be sure that the return is sufficient to justify giving up the value of this additional information.

The value of this option can be quantified, based upon the underlying volatility and trend of the investment, and the company's cost of capital. This research creates an explicit linkage between traditional NPV analysis and the option valuation approach, before considering a whole new set of policy instruments designed to increase a company's likelihood to invest. The research develops several potential new instruments, screens them for the desired behaviour, and selects the most promising instrument. The new instrument is then validated by using an investment case example adapted from the public domain and a large computer model.

The research also discusses several related areas. It describes the effect of overlaying Poisson type events on an investment decision (i.e. a sudden shift in the value of the investment), and draws the implications of this thinking on the policy approaches that should be taken by incumbent and opposition regional policy makers. Lastly, the research includes a review of the U.K.'s regional policy objectives and an analysis of different approaches to corporate investment decision making.

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# Chapter 1

# Application of Option Pricing Techniques to United Kingdom Inward Investment Policy

## 1.1 Overview of the research

Many developed and developing countries suffer from a "regional problem": a part of the country with significantly lower levels of economic development, overall wealth and attractiveness to investors. The existence of these regions tends to be self reinforcing, as a cycle of general neglect, government underinvestment (e.g., in infrastructure) and limited corporate investment sets in. As a result, nearly every government has both national and regional policies intended to break this negative cycle (see for example Yuill et al, 1980- for a comprehensive description of European approaches).

Some of these policies are intended to address aspects of the "social safety net" (e.g., improving the level of unemployment benefits or job training skills). Other policies include investment incentives, infrastructure building programmes, government purchasing schemes and a wide range of other types of intervention.

While the approaches taken to resolving regional problems vary greatly, both across countries and regions, and over time, Dicken and Tickell (1992) have noted that "the promotion of inward investment runs like a continuous thread through the 'changing fads, fashions, and ideologies' (Robinson, 1990) of regional and local economic development policies." This investment promotion often takes the form of policy instruments designed to improve the short term attractiveness of a given investment to potential investor companies. The companies on their part then apply a number of well understood techniques to evaluate the relative attractiveness of potential investments in different locations, both within a country and between countries. They can then decide whether or not to invest, and where to invest.

In making these assessments, potential corporate investors rely heavily upon calculations of the Net Present Value (NPV) of the expected future cash flows from a given investment.[1] Having determined the discounted value of these cash flows, they then compare the value with the initial investment cost, taking into account any subsidies or other incentives from

[1] Chapter 4 gives a brief description of this analytical approach.

development agencies. The traditional approach is to invest in a given project if the present value $V$ exceeds the initial investment cost $I$, having incorporated a suitable discount rate into $V$. The ratio of $\frac{V}{I}$ will be denoted as the critical ratio, $C^*$. In the traditional approach, then, the decision rule is for a company to invest if $C^* \geq 1$.

Relatively recent research (McDonald and Siegel, 1986), however, has shown that this approach is not sufficient, because it neglects the value of the additional information that will be received if the decision to invest is made in the future.[2] For example, if a company waits before making its investment, it will learn additional information about the market, such as factor cost levels (e.g. labour rates) and macroeconomic information (e.g. inflation rates). The value of this additional information can be considerable. McDonald and Siegel have discovered that for reasonable economic parameters, it will be appropriate for a company to invest when $V$ is 2 or more times the size of $I$, i.e. a $C^*$ of 2.

This startling result is not widely known, even among sophisticated corporate investors and government policy makers. Most investment policy instruments are directed either at reducing the size of $I$ (e.g. through equipment subsidies, provision of rent free facilities) or at increasing the value of $V$ (e.g. through preferential tax or depreciation rates). Both of these approaches improve the likelihood of a company making an investment under the traditional decision making approach. These

[2]Appendix A describes their analysis in detail.

instruments can also have some impact on $C^*$ in the McDonald Siegel approach. Mathematical research has shown, however, that the volatility of inputs to $V$ (e.g. labor cost, exchange rates), as opposed to absolute level, can also be an important driver of $C^*$. Thus it is possible to consider a whole new set of policy instruments designed to increase a company's likelihood to invest, based exclusively on reducing uncertainty about the future. For example, a government might agree to assume the risk of fluctuations in labour costs to reduce the uncertainty about the future, thereby reducing both the amount of direct subsidy required to encourage immediate investment and the average time to investment.

The overall objective of this research, therefore, is to develop and assess a new set of policy instruments designed to stimulate investment, and to identify recommendations for investment policy makers based upon this work. In particular, I have developed an intellectual bridge between a body of theoretical economics and typical approaches companies use to make investments; developed a detailed case example and computer model to implement the new approach; and identified and screened several potential new policy instruments using this case example and model. This analysis therefore builds on existing academic work in economics and corporate finance, but applies the concepts in a new way to inward investment policy. The new potential policy instruments described here are applicable to both inward investment (i.e. by overseas companies) and local investment, and therefore both aspects will be discussed. The thrust of the research, however, is focused on inward investment policy. Note that for the purposes of this thesis, the terms Foreign Direct Investment (FDI) policy and inward investment policy are considered to be interchangeable.

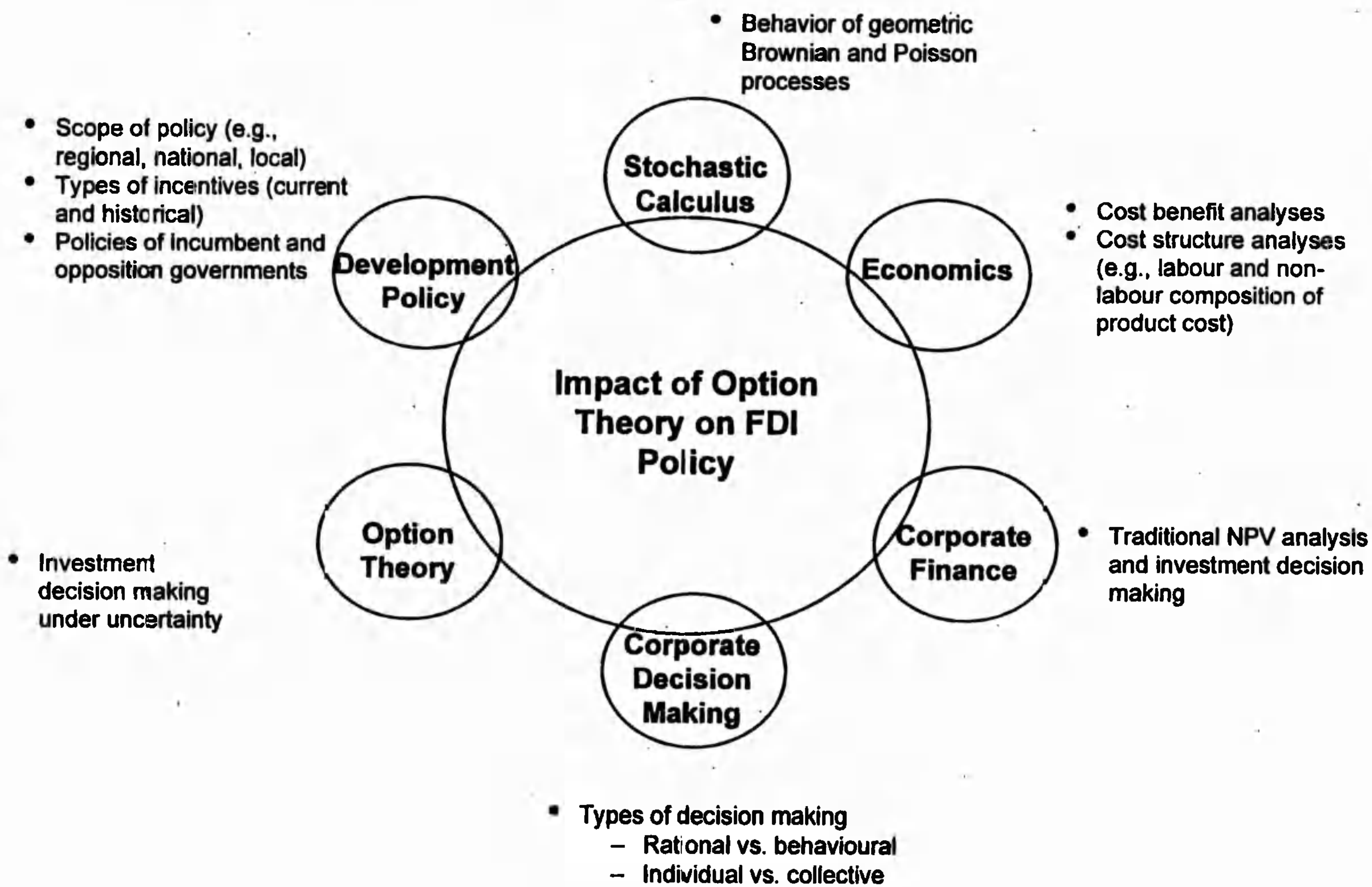
This research draws upon insights from a number of different fields (Figure 1.1). Hilhorst (1990) has noted that "regional studies as a field originated in various interrelated concerns and disciplines." Thus this work can be considered a logical extension of the interdisciplinary character of the field. The analysis relies upon several key mathematical concepts from stochastic calculus (i.e., the mathematical treatment of the behaviour of uncertainty) and option theory. It also draws on economics, corporate finance and theories of corporate decision making to identify how companies currently make investment decisions and how they should do so in light of the mathematical treatment of uncertainty. Most importantly, the research draws upon key aspects of development policy, including objectives of inward investment policy and the relative emphasis the government places on different types of national policy instruments.

## 1.2 Rationale for study of the U.K.

The U.K. represents an excellent country to study in the application of a distinctively new policy approach to a Western democracy. As Yuill (1980) has noted, "Regional policy in Britain has a much longer history than in the remaining Community countries and has encompassed a greater variety of policy measures than any other regional package in the Community." These measures include the service industry-grant scheme, the factory

Figure 1.1:

**INTELLECTUAL DISCIPLINES REFLECTED IN THIS RESEARCH**



building programme and the now defunct Industrial Development Certificate programme (but while operational, one of the few effective location controls in the Community). As further evidence of the U.K.'s policy leadership role, especially in Northern Europe, Bachtler and Michie (1993) note that in the early 1980s, Britain was one of the first countries to reduce the geographic spread of assisted areas, prompting a number of countries to launch similar initiatives.

A second reason for studying the U.K. is the evidence that investment promotion has a significant impact on companies' decisions to invest. This finding makes the U.K. environment a logical one to study in the application of new policy approaches. For example, the 1992 Japan External Trade Organization found that aggressive invitation from investment promotion was the third most important factor out of 15 for companies selecting the U.K. as their investment base (behind only the fact that the U.K. speaks English and the quality of the transportation, communication and other infrastructure).

The third reason for selecting the U.K. is the substantial resources that are made available for investment subsidies in the U.K.. Martin (1993) has estimated that the level of assistance was approximately £400 million in 1993, in just the Scottish Enterprise (formerly the Scottish Development Agency) and the Welsh Development Agency combined. Metcalf (1984) estimated that total expenditure on industrial support was £12.7 billion in 1980, a full 6 % of GDP. This broke down into four categories: investment incentives (£6 billion), support for particular sectors (£3.1 billion), research and development (£2.4 billion) and manpower subsidies (£1.2 billion). Clearly this is an important area for study, given the magnitude of these numbers.

## 1.3 New aspects of the research

The research presented here adds to existing thinking in seven main areas:

- Identifying broad themes from sixty years of U.K. regional policy (Chapter 2).
- Providing a general framework to assess a country's attractiveness for investors (Chapter 3).
- Linking the McDonald Siegel research to traditional firm decision making approaches, and developing a substantial computer model to implement this linkage (Chapters 4 and 5).
- Identifying a comprehensive set of potential policy levers and designing policy instruments based upon them (Chapter 6).
- Analysing these instruments to determine whether or not they motivate the desired investment behaviour, and - where relevant - assessing their costs and benefits (Chapter 6).
- Applying the most promising policy instruments to a detailed case example (Chapter 6).

- Identifying the implications of the analysis for U.K. investment policy (Chapter 7).

## 1.4 Overall structure of the research and methodology

This thesis is in six additional chapters, as follows:

- **Chapter 2** sets out the general elements of regional policy, and arrays the U.K.'s current policy objectives against them. It also describes and evaluates a number of existing policy instruments, and identifies additional areas in which option theory could be applied to policy setting (e.g. infrastructure building). The chapter draws upon a number of different secondary sources and a few primary sources to describe five eras of U.K. regional policy.

- **Chapter 3** develops a general framework to assess a country's attractiveness for investment, and applies this framework to the U.K. The chapter also provides an overview of plant location decision making approaches, both rational and behavioural. The chapter relies upon literature research as well as interviews and discussions with corporate decision makers and government investment policy makers.

- **Chapter 4** begins with a brief review of traditional Net Present Value analysis (the primary tool used by companies to make investment decisions). It then develops a five step process to link the

McDonald and Siegel approach to traditional firm investment decision making. In terms of sources, this chapter draws upon the original McDonald and Siegel analysis and standard investment making tools as described in Brealey and Myers (1991).

- **Chapter 5** describes the primary case example used in the thesis. The case is based upon detailed field work and analysis conducted by myself and a colleague (Cerny and Bartmess, 1992), although disguised for confidentiality[3] and modified to correspond to a greenfield investment decision in the U.K. This chapter also describes in detail the model used to test the new policy instruments.

- **Chapter 6** forms the core of the analysis. Based upon the mathematics described in Appendix A, it systematically describes and analyses four possible types of policy instruments. Of the four, two encourage the reverse of the intended behaviour (as seen in the following section, this type of counter-intuitive result is relatively common in this field). Of the remaining two approaches, one provides a practical new policy instrument, and this instrument is described and analysed in detail. The other remaining approach validates some research findings on the impact of policy divergence between incumbent and opposition political parties, and provides fresh insights into policy approaches (especially policy pronouncements) by both parties.

[3]The methodological implications of this step are discussed in more detail in Section 5.1.1.

- **Chapter 7** summarizes the methodology and results of the thesis, and distils the implications for U.K. development. It concludes with a few insights on the implications of the analysis for corporate investment decision making. The chapter draws upon some published research to set the recommendations in a broader context.

- **Several appendices** describe the underlying mathematics in detail, summarize the author's interviews and provide a sample of the detailed output from the investment model.

## 1.5 Related work in development policy

The analytical techniques described and applied here are based upon work by McDonald and Siegel (1986) and further described in Dixit and Pindyck (1994). Direct application of these ideas to develop specific policy instruments is original work, to the best of the author's knowledge.

The research in this thesis links to four aspects of existing research:

- **Amplification of impact of uncertainty.** Several authors have noted that relatively small amounts of uncertainty can have a major impact on a company's likelihood to invest. Rodrik (1990) has developed an econometric model that assesses the impact of uncertainty regarding the longevity of economic reforms for both small and large policy reversals. In his model, and using typical figures, companies require a significant investment subsidy to offset even a 10 % probability of reversal. For small reversals, companies require a premium over alternative investments which is 80 % of the initial policy benefit, even with a probability of reversal of only 10 %. My own work supports this amplification phenomenon, and will be discussed further in case 8 of Section 6.4.3.

- **Counterintuitive results.** MacKie-Mason (1990) has analyzed the effects of nonlinear tax rates, and has discovered that some of the economic incentives applied to mineral extraction (e.g. the percentage depletion allowance) may actually have the reverse effect of what is intended once the interaction between tax rates and economic uncertainty is included. In addition, increasing the corporate cash flow tax may actually **increase** a company's likelihood to invest, once the interaction with the percentage depletion allowance is taken into account. The existence of these types of counterintuitive results is reflected in my research. As is described later in more detail, two apparently "reasonable" policy instruments (one of which is in common use) actually **reduce** a company's likelihood to invest if they are analyzed properly (See Sections 6.1 and 6.3.2).

- **Asymmetries.** Majd and Myers (1986) have explored tax asymmetries (i.e. in government policy differences as applied to corporate losses vs. profits) by combining option pricing theory with Monte Carlo simulation. They conclude that these asymmetries can have a substantial impact on the net present values of investment projects. Although my research relates primarily to symmetrical investment incentives, the important issue of bankruptcy on the cost of providing the key new policy instrument is discussed in Section 6.2.3. In this case, the existence of the asymmetry works in favour of the government, by reducing the average cost of subsidizing investment and therefore affecting a company's likelihood to invest.

- **Impact of policy uncertainty and divergence on investment.** Aizenman and Marion (1991) have attempted to link GDP growth to policy uncertainty for 46 developing countries. In general, they find that the correlation is typically negative (the expected result), but there are also cases where the correlation is positive or nonexistent. Given the highly macroeconomic nature of their analysis, it is not surprising that there are some exceptions to the overall pattern. They have also developed an economic model in which policy can fluctuate between a high-tax and low-tax state. If policy fluctuates randomly between the two states, then the degree of uncertainty between the two states (i.e. the divergence) has no impact on investment behaviour unless the policies are persistent (i.e. have a greater than 50 % chance of being retained). If they are persistent, then more uncertainty does alter the pattern of investment. They also conclude that small divergences in policy have a limited impact on investment. My research is based on a single event model (i.e. the possibility of a single shift between policy regimes), and agrees with one of their key findings: it shows that wide divergence between policy regimes has a strongly depressive effect on investment when the country is in the less attractive regime (see, for example, Figure 6.6). While this result appears intuitively clear, it is important to verify it quantitatively, especially given the possibility for counterintuitive results noted above.

Some of the papers cited here will be discussed in more depth in the relevant sections.

## 1.6 Limitations of the analysis and potential for further work

Given the potential breadth of application of option pricing theory to investment policy, this thesis has focused on defining and analysing a potential set of policy instruments, applying them where appropriate to a particular investment decision, and identifying the implications for U.K. policy. It addresses only briefly the question of whether stimulation of inward investment is an economic good, but rather focuses on how resources should be applied to achieve the maximum impact. As a further mechanism to reduce the scope of the analysis to a manageable level, this research:

- **Focuses on investment incentives** as the primary instrument to encourage inward investment. It excludes detailed analysis of other potential approaches to stimulate inward investment (e.g. infrastructure development, geographic distribution of government orders). The emphasis here is also upon efficient application of government resources to stimulate inward investment, not whether the goal itself is appropriate (although reference is made to this issue in Section 2.2).

- **Focuses on manufacturing investment.** There are, in fact, three main categories of regional policy analysis: manufacturing firms, service firms and agriculture. This thesis focuses exclusively on manufacturing firms, although the principles could be applied to service firms as well. Work by Conway (1988) on private investment in the Turkish economy between 1962 and 1986, as discussed in Rodrik (1991), notes that the impact of policy uncertainty on investment is greatest by far in the manufacturing sector. This finding suggests that my emphasis on the manufacturing sector is appropriate.

- **Assumes the investing company is able to delay investment.** The analysis presented here assumes that the investing company is able to delay the investment, at least for a period of time, without losing too many of the benefits (e.g. from pre-emptive competitive activity). Pindyck (1991) has noted that this is not always the case; however, he remarks that in most cases, delay is at least feasible.

- **Emphasises greenfield investments** over plant relocations. The instruments developed and discussed in this document have been applied to greenfield investments. The underlying methodology could easily be extended to plant relocations, however.

- Has some specific **technical limitations** in the application of the McDonald Siegel work:
  - **Irreversibility of investment.** The model used in this analysis assumes that the investment is irreversible, i.e. once made the investment cannot be recovered. Pindyck (1991) notes two reasons for an investment to be irreversible. First, the capital may be firm or industry specific, making it difficult or impossible to redeploy the resources economically. Second, there is the "lemons problem": some new equipment such as computers, cars and office equipment has resale value below its purchase price, even when virtually brand new. This makes investments at least partially irreversible. It is possible to imagine circumstances, however, where the investments are at least partially reversible, and it would be possible in principle to extend the McDonald Siegel analysis to these cases.
  - **Assumption that key variables follow geometric Brownian motion with drift.** This constraint could be relaxed to allow variables to follow non-Brownian motion, although the model would then require some modifications.
  - **Infinite life span of project.** The project is assumed to continue indefinitely, once the initial investment has been made. This is a typical assumption in many investment projects, since cash flows from the relatively short to medium term contribute most of the value of the project. However, the models used

could, in principle, be modified to permit analysis of projects with more finite life spans.

- **Fixed cost of capital.** Some analytical models allow the company's cost of capital to vary over time (see Chapter 4 for a brief discussion of the role of cost of capital in investment decision making). In the interest of mathematical tractability, however, it is assumed that the investing company's cost of capital does not vary.

## 1.7 Summary

This chapter began by describing a key finding in investment decision making theory and indicated its applicability to the particular regional policy issue of inward investment policy. It then provided a brief rationale for applying these concepts to inward investment policy in the U.K.. Next, it described the new aspects of the research, outlined the structure of the thesis and the underlying methodology, and related the findings of the research to four recurrent themes in the related literature. Lastly, it described some opportunities to extend the analysis.

Chapter 2 that follows discusses government regional policy and inward investment policy objectives, as well as several other important themes such as minimising excess competition for investment. Chapter 2 thus provides a broad context for the discussion in Chapter 3 of the plant location decision making process, both in terms of how companies assess a country's inherent attractiveness for investment and how companies make investment decisions.

# Chapter 2

# The Role of Government Policy in Encouraging Foreign Direct Investment

This chapter discusses the role of the government in encouraging inward investment, and leads into a discussion of corporate investment decision making in Chapter 3. These two chapters together therefore create a context within which the discussion of potential policy instruments in Chapters 4, 5 and 6 can be placed.

The chapter begins by introducing a framework, based on research by Vanhove and Klaasen (1986), that describes a comprehensive set of regional policy levers. Next, it provides a historical perspective on U.K. regional policy, before reviewing the objectives of the Thatcher/Major government approach to inward investment. It then discusses the relative emphasis of different types of policy instruments in use and assesses their relative cost and selectivity. Next, it describes the potential application of option pricing approaches to six different categories of investment policies. Finally, it describes the rationale for selecting the particular area considered in the rest of the document, i.e., application to financial incentives.

## 2.1 Elements of regional policy

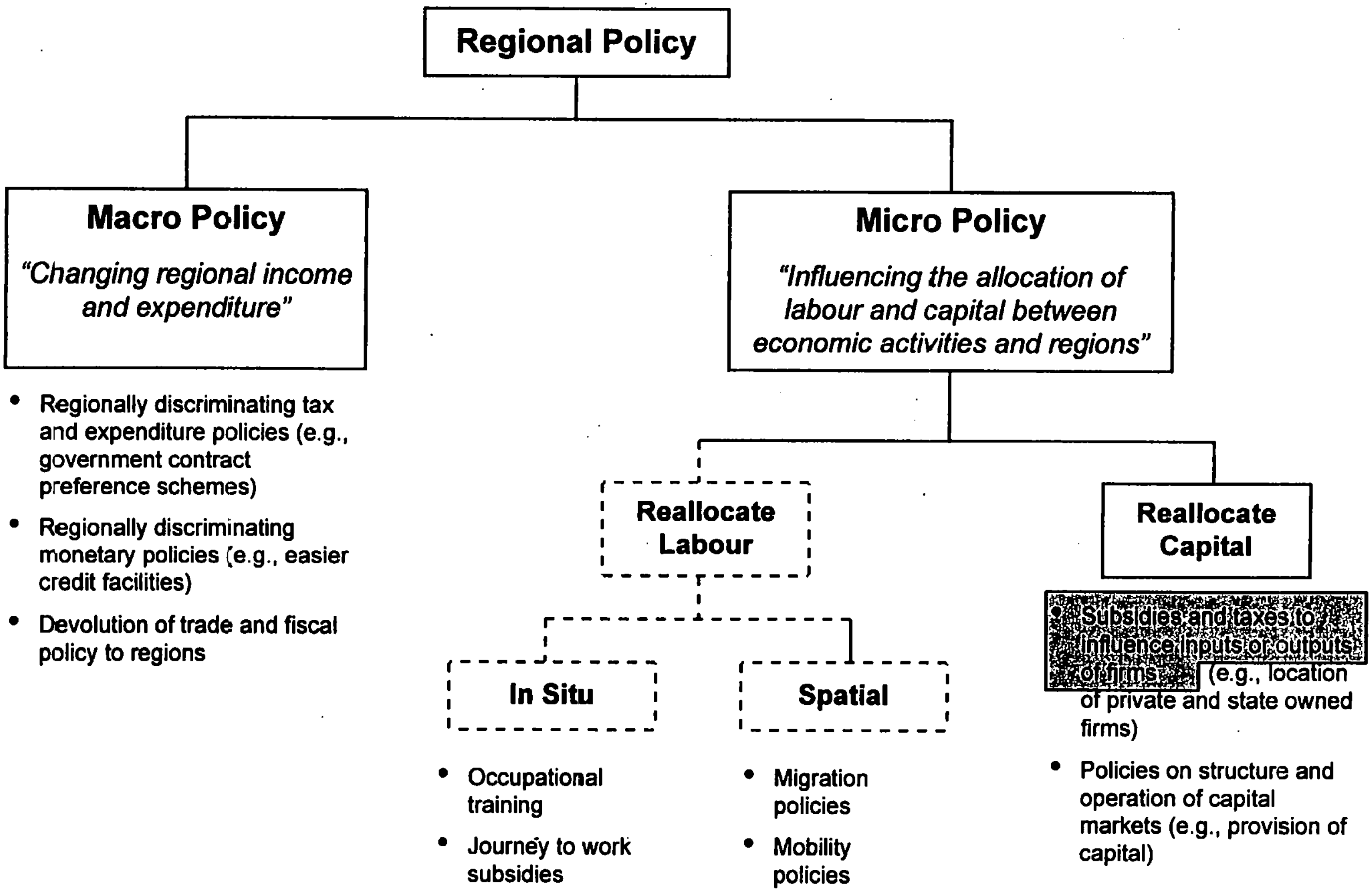
Vanhove and Klaasen (1986) have identified a number of elements of regional policy; these are summarised in Figure 2.1. These authors divide regional policy into macro and micro policy. Macro policy seeks to influence "regional policy and expenditure." Micro policy seeks to influence "the allocation of labour and capital between economic activities and regions." Micro policy is then divided further into policies that reallocate labour and policies that reallocate capital.

The balance of activity in U.K. policy setting over the last 50-60 years has been by no means even across all the regional policy elements, however. As will be seen in Section 2.2, U.K. regional policy has given very little emphasis to reallocating labour, either in situ or spatial (i.e. physical transfer of people). Far more important has been the reallocation of capital within the context of overall micro policy, and the research presented here will focus on this policy area. The levers used to implement reallocation of capital include subsidies and taxes to influence inputs or outputs of firms

Figure 2.1:

## ELEMENTS OF REGIONAL POLICY

Focus of research




*Source: Vanhove and Klaasen*

(and by extension, their actual location). The government spends significant resources every year in this area, both in foregone taxes and actual outlays for subsidies, and therefore examining ways to improve the efficiency and effectiveness of these levers is an important topic. In order to frame current activity in this area, the next section presents an historical overview of various aspects of regional policy.

## 2.2 Historical overview of U.K. regional policy

Before reviewing current government posture towards inward investment in detail, it is helpful to provide a perspective on major eras of U.K. regional policy (Figures 2.2 and 2.3). This analysis draws upon Yuill et al (1980), Brech and Sharp (1984), Vanhove and Klaasen (1986), Gibbs (1989), Bachtler (1990), Dicken and Tickell (1992), Martin (1993) and Collis and Noon (1994). As Aizenman and Marion (1991) have noted, there is evidence in developing countries that policy is persistent, and this policy persistence is also reflected here: the broad shape of U.K. regional policy has changed very little since its inception.

Broadly speaking, U.K. Regional policy can be broken down into 5 main eras (Yuill et al, 1980 have identified the first three, and I have added the final two). For purposes of this analysis, special provisions for Northern Ireland have not been identified explicitly, but are included in the broad

# Eras in U.K. Regional Policy

| | Early Experimentation/ Post War | Rapid Change/ Experimentation | Expenditure Growth and Decline | Early Thatcherism | Focus on Selective Assistance |
|---|---|---|---|---|---|
| *Timing* | *1934-1959* | *1960-1972* | *1972-1979* | *1979-1988* | *1988-Present* |
| **'Trigger' for Era** | Recognition of regional disparities | Recession of 58/59 | Labour government | Conservative election victory | DTI 1988 White Paper; abolition of automatic grants |
| **Policy emphasis** | | | | | |
| **– Automatic vs. discretionary aid** | —— | Trend towards automatic | Automatic | Automatic for grants, discretionary for loans/interest relief (needs based) | Discretionary |
| **– Central vs. regional balance** | Centralized | Centralized | More local | Devolution of policy administration (but clashes between local and national) | Decentralized (but counteracts radical authorities) |
| **– Grant vs. fiscal aid** | Both | Frequent switching | Grant oriented | Grant oriented (item not project) | Grant oriented (project related) |
| **Development bodies** | —— | —— | • Scottish, Welsh Devel. agencies created<br>• IBB created (1977) | • Urban development corporations (UDCs) established 1980 | |

Figure 2.3:

# ERAS IN U.K. REGIONAL POLICY

| | Early Experimentation/ Post War | Rapid Change/ Experimentation | Expenditure Growth and Decline | Early Thatcherism | Focus on Selective Assistance |
|---|---|---|---|---|---|
| ***Timing*** | ***1934-1959*** | ***1960-1972*** | ***1972-1979*** | ***1979-1988*** | ***1988-Present*** |
| **Key policy instruments** | | | | | |
| **– Grants** | Provided | Various | Rapid increase until 1976, then cutbacks | Regional Development Grant key element of package until 1988 | Regional Selective Assistance key element |
| **– Loans** | Loans to private industries (1938) | ——— | Available selectively | Available selectively | Available selectively |
| **– Fiscal measures** | Tax subsidies (until 1945) | Various | Limited | Limited | Limited |
| **– Development regions** | Special areas-1934 (depressed coal mining regions) | Development Districts (1960) changed to Development Areas (1966) | Special Development Areas, Development Areas, Intermediate Areas | Phased reduction of scope of SDAs, DAs, and IAs | DAs and IAs only: shift in emphasis to South in 1993 map |
| **– IDCs** | Launched in 1948 | In force | Extended to offices in the Southeast (1965) | Suspended in 1981 | None |
| **– Factory building** | Launched after WWII | Ongoing | Ongoing | Ongoing, but emphasis on self-finance | Very limited? |
| **– Other** | Industrial transference bound to aid worker moves - dropped in 1938 | Regional Employment Premium (1967-1976) | Regional Employment Premium (ended 1976) | Exchange controls lifted (1979) | |

policy approaches shown in Figures 2.2 and 2.3. The five eras are as follows:

- **Early experimentation/Post War.** The existence of national disparities in wealth was recognised as early as the 1920s, when certain areas of the country experienced extremely high unemployment (e.g. N. Ireland, Scotland, the North of England, S. Wales). Many of the key aspects of the U.K. approach to regional development were put in place within a decade: the provision of grants; the creation of development regions; the implementation of Industrial Development Certificates as a disincentive programme; and the factory building program. All of these elements remained in some form or another for long periods of time, and some (e.g. grants and development regions) are still in place. Interestingly, the government experimented with moving workers to jobs via the Industrial Transference Board, which was disbanded in 1938; this represents the government's only experimentation with spatial labour reallocation in nearly 70 years of policy making.

- **Rapid change/experimentation.** Regional policy was relatively unimportant as an issue after the war until 1958/1959, when a severe recession refocused government attention on the area. In this period, the government switched frequently between grant and fiscal incentives, while trying to meet overall objectives of increased employment and improvements in the balance of payments. New regions were created, first Development Districts (1960), then Development Areas (1966). One key aspect of this era was the increasing trend towards automatic aid, a feature that persisted until the 1980s. The Regional Employment Premium was also launched in this era; this incentive provides an important precedent for one of the policy instruments developed in this research, and will be discussed in greater detail below (see Section 2.5.3).

- **Expenditure growth and decline.** The election of the Labour government in 1972 provided the initiating event for the next era of development policy. In this era, the level of grants awarded increased dramatically until 1976, before a period of cutbacks took place (expenditure on the Regional Development Grant alone was £400 Million in 1976/77). In this era, three new types of development regions were also created: Special Development Areas, Development Areas and Intermediate Areas. While these three types of areas have now been consolidated into two, this broad framework is still in use today. The REP was discontinued in 1976, but the factory building programme and the IDC system were preserved. Significantly, the Scottish and Welsh Development agencies were also created in this era. The Invest in Britain Bureau was created in 1977 to promote the U.K. at large and coordinate the activities of the regional agencies. Despite the cutbacks in expenditure at the end of this era, regional assistance was provided to a large proportion of the country. For the last three years of this era, a remarkable 45% of the U.K. (including Northern Ireland) was designated as an assisted area, the highest in the community (Yuill et al, 1980). Belgium was the only other country in the community with over 40% of its population included in Development zones.

- **Early Thatcherism.** Following the Conservative election victory in 1979, the government followed a more free-market approach to regional policy and therefore sought opportunities to minimise the government's role (although the political importance of job creation led to regular compromises). Perhaps responding to the financial largesse of the previous era, the government's stated aim was to reduce public expenditure, concentrate on areas of greatest need, and increase the cost effectiveness of regional policy. The government continued its emphasis on automatic aid for grants, but increased its latitude in loan provision. In particular, it placed greater emphasis on providing financial assistance only where it was demonstrably necessary for a given project in order for it to go ahead. Also in this era, the areas covered in Special Development Areas and Intermediate areas were reduced.[1] The factory building programme was preserved, but with a greater emphasis on self finance, and the threshold level for Industrial Development Certificate exemptions was raised, reducing its impact somewhat. The government also lifted exchange controls, a highly significant, if largely symbolic, step.[2]

[1]These remained constant at 35% of the country between 1985 and 1992, per Bachtler and Michie(1993).

[2]The 1947 Exchange Control act was only applied very loosely. Hodges (1974), cited in Brech and Sharp (1984), noted that less than half a dozen applications were refused in 32 years of operation.

- **Focus on selective assistance.** Since the publication of the Department of Trade and Industry White Paper in 1988, "the whole tenor of policy has changed" (Gibbs, 1989). In particular, the White Paper totally abolished automatic grants, one of the key features of U.K. regional policy until then, and encouraged a very free market oriented policy. To quote the White Paper, "..sensible economic decisions are best taken by those competing in the market place. The responsibility of government is to encourage the right climate so that markets work better and to encourage enterprise." In this era, the government has also developed a new structure to promote and oversee inward investment. As Dicken and Tickell (1992) have noted, inward investment promotion in England now follows a hierarchical structure, with the IBB overseeing three territorial agencies (the Welsh, Scottish and N. Irish agencies) and five promotional agencies - the RDOs - which operate in England and almost always focus on pure investment promotion. Martin (1993) has noted that since the redrawing of the map of assisted areas in 1993, there has been a significant shift in emphasis for development aid from North to South. This is perhaps unsurprising given the severe recession of the early 1990s, which hit the Southeast especially hard. Lastly, in this era, the government has also given greater emphasis to small and medium companies, although grants are still available for large companies.

Having laid out the five main eras of U.K. development policy, it is helpful to articulate the themes which have remained consistent over these eras. Later on in this thesis, it will then be possible to ensure that the final policy recommendations are consistent with them. The themes are as follows:

- The first theme is the **continuing need for intervention**; despite over sixty years of regional policy, significant regional disparities remain. This intervention has tended to emphasise the same set of regions suffering from the legacy of past heavy industry and mining, but even parts of the Southeast have been considered suitable targets for intervention in the early 1990s.

- The second theme has been the underlying assumption - shared by both major political parties - that **inward investment has had a net positive effect** on regional development, and therefore should be encouraged. [3] The policy lever of choice in encouraging such investment (at least since 1972) has been grant oriented incentives and selective loans, rather than fiscal aid.

[3]Some authors challenge this orthodoxy. Cowling and Sugden (1993), for example, take a skeptical view. They write "...the approach of successive governments, whether Conservative or Labour, has been typified by a largely unqualified acceptance of the case for inward investment; see Sugden (1989). There has been little monitoring of its actual consequences and yet it would seem clear the belief in its alleged benefits, in terms of balance of payments, employment, and technology base are not built on particularly secure foundations. Whilst temporary gains may be observed, a long-term commitment to locations in Britain cannot be assured, and even where an investment of longer-term duration is made it cannot be assumed that such activity is congruent with the national interest."

- The third theme has been the government's traditional **emphasis on automatic aid**, i.e. aid is provided automatically if companies fulfil certain criteria. This theme persisted between about 1960 until the era beginning in 1988, when the government shifted its approach towards a more selective one. Given the government's current financial constraints, the trend towards increasingly discretionary aid is unlikely to be reversed. This theme, therefore, is probably not helpful in anticipating future policy approaches.

- The final theme is the **government's willingness to experiment with novel approaches**, often taking a leadership role among European countries. These approaches would include the REP, the Service Industry Scheme, the factory building programme and the Industrial Development Certificate programme.

Less consistent over the eras has been the overall financial level of support, the balance of central versus regional intervention and the scope of assisted areas (i.e., the percentage of the population covered).

## 2.3 Foreign Direct Investment policy objectives

This section discusses the broad range of potential objectives of investment policy and U.K. objectives in the most recent era described above.

### 2.3.1 Broad framework of policy options

Hilhorst (1990) has developed a compelling framework on regional development policy options which allows the U.K.'s general approach to be put in context. Later in this section, more specific policy objectives will be discussed, based on work by Brech and Sharp (1984) and others. Hilhorst defines five sets of options, which can be combined into policies of different levels of coherence: growth versus (income) distribution; functional versus territorial integration; private sector-led versus public-sector led development; concentration vs. dispersion; and migration versus capital aid. Growth vs. distribution can be through of as the choice between maximum growth and balanced income distribution. Functional versus territorial integration is based upon work by Friedmann and Weaver (1979), and can be thought of as the extent to which the history of a location should determine its economic role versus interregional specialization based on interregional trade and territorial advantage. As Hilhorst notes, these first two sets of options are closely related. The third set of options is private sector-led versus public sector-led development; he follows here the traditional definition. Concentration versus dispersion is the decision to limit major share of investment to one (or a very few) locations in the country versus trying to stimulate investment in as many places as possible. Lastly, migration versus capital aid can be thought of as "people to the jobs" versus "jobs to the people".

Having defined these five elements, Hilhorst permutes all of the possible combinations, leading to 16 different types of policy. He then assesses each for coherence (i.e. internal consistency) and identifies countries that have followed different approaches. Western Europe (including the U.K.) has generally followed his option 4, i.e. growth oriented, private led, dispersed investment rather than concentrated and capital led rather than migration oriented.[4] He has identified a number of diverse alternative approaches, reflected by Mao's China, the Ivory Coast, Cuba, Poland and others.

Having described the most broad conceptual parameters of U.K. regional policy, we can now examine more specific policy areas. Drawing upon the work of Brech and Sharp (1984) and other authors referred to in this chapter, I have identified six main types of objectives of overseas investment policy:

- **Primary job creation.** Creating jobs directly from inward investment is frequently a goal of regional development agencies. Indeed, many agencies use this as the primary criterion when evaluating whether or not to provide governmental support.

- **Secondary job creation.** Secondary job creation refers to job creation not directly related to the initial investment (e.g. through increased employment at suppliers or distributors).

[4]Despite Norman Tebbit's famous admonishment for young people to "get on your bike" to move to employment, policies under the Thatcher administration strongly favoured capital over migration policies.

- **"Stalking horse" for other corporate functions.** Rather than trying to encourage the formation of entire new companies in a country, a government agency can attempt to encourage functions to move in sequence to their country. For example, a country could attempt to attract manufacturing investment first, followed by manufacturing engineering, R & D, and perhaps ultimately marketing and sales.

- **Stimulus for domestic industry.** Encouraging local investment to simulate greater competitive ability in indigenous firms is a relatively common policy objective. As Brech and Sharp (1984) note, overseas investment can even stimulate gains from trade in industries which are "non-tradable" (i.e., products otherwise sheltered from competition by relatively high transport costs, such as cement).

- **Capital investment.** Some governments seek to encourage capital investment for its own sake, in the apparent belief that it will stimulate a proportionately higher level of job creation. In fact, the reverse is often true in a modern economy: heavy industry which has high capital requirements may generate far fewer jobs than "knowledge based" industries such as electronics and professional service firms.

- **Encouraging particular industries.** Lastly, some governments seek to attract particular types of investment, in order to build competitive strengths in particular areas. Scottish Enterprise, for example, has identified "high potential" sectors, and also provides investment where the private sector is unable to provide all the necessary funding (e.g. high risk ventures in high technology).

The relative balance of the U.K.'s adoption of these policy objectives will be discussed in the following section.

### 2.3.2 Objectives of U.K. FDI policy

Overall, the U.K. has adopted a very encouraging stance towards foreign direct investment.[5] Relative to other EC countries in the 1980s, it took a middle position in terms of level of subsidy, except in Northern Ireland where it adopted one of the most aggressively subsidy oriented approaches (Yuill and Allen, 1986, cited in Vanhove and Klaasen, 1986). Gibbs (1989) has also noted that both Reagan and Thatcher have "declared aims of breaking the cycle of negative expectations, renewing national optimism and confidence and encouraging a "general climate" which is conducive to efficient and competitive production."

Within the broadly encouraging stance noted above, the relative importance of the six potential objectives identified above for U.K.

[5] While the national stance has been highly welcoming towards inward investment, Collis and Noon (1994) describe some of the negative attitudes in the 1980s of the more radical Metropolitan Councils. These councils questioned the value of inward investment and challenged the potential benefits, due to concerns over the quality of employment and the risks of excessive competition for inward investment.

investment policy is as follows (see Figure 2.4)[6]:

- **Primary job creation - Very high level of emphasis.** This has been one of the two key objectives of U.K. regional policy (the other has been stimulating capital investment). In the current policy regime, Regional Selective Assistance requires job creation or preservation as a precondition for an award.

- **Secondary job creation - High level of emphasis.** Although not explicitly incorporated as an objective, it is widely recognized by the government that primary investment often leads to secondary job creation.

- **Stalking horse for other functions - Low level of emphasis.** While the argument is often made that U.K. companies risk "hollowing out" their expertise by exporting their manufacturing functions (i.e. that other high value added areas such as design and R &D will follow), **attracting** these functions has not featured prominently as an objective of U.K. investment policy.

- **Stimulus for domestic industry - High level of emphasis.** The Secretary of State for Industry explicitly recognized this objective as being important in a 1982 paper for the National Economic Development Council (NEDC 1982, quoted in Brech and Sharp, 1984). The Secretary also used this paper to restate the government's

[6]The analysis presented here is based upon work by Yuill et al (1980), Gibbs (1989) and other sources mentioned above.

# OBJECTIVES OF U.K. INVESTMENT POLICY

● = High Importance
○ = Low Importance

| Policy Objectives | Degree of U.K. Emphasis | Rationale |
|---|---|---|
| 1. Primary job creation | ● | • Traditional focus of investment policy<br>• Regional Selective Assistance requires job creation or reservation<br>• Grant assistance linked more closely with job aid from 1984 onwards |
| 2. Secondary job creation | ◕ | • Secondary focus, but recognized as important |
| 3. "Stalking horse" for other corporate functions | ◔ | • Rarely articulated as policy objectives, although concerns over the 'Branch Plant Economy' are common |
| 4. Stimulus for domestic industry (e.g., through increased competition) | ◕ | • Referred to explicity by the Secretary of State in a Jan. 1982 white paper and subsequent documents |
| 5. Capital investment | ● | • Traditional focus of investment policy (implied link often made between capital investment and job creation) |
| 6. Encouraging particular industries | ◔ | • Policy more region focused than industry focused (e.g., discretion in loan projects generally based upon viability, not specific industries)<br>• Special incentives are available for investments in high technology areas |

commitment to free operation of market forces: "The Government is committed to maintaining and strengthening the operation of market forces in order to improve the country's economic performance. A free flow of inward investment contributes to this central policy objective by introducing additional productive capacity to compete with established sources in the U.K. and with imports, as well as to raise exports. Such investment, often bringing new technological skills and managerial expertise, tends to increase both the quality and the quantity of output and employment in this country." The objective of stimulating inward investment to provide a model to domestic industry and as a way of building the strength of the economy was reiterated in the 1988 White Paper entitled "DTI - The Department for Enterprise." (Cited in Strange, 1995).

- **Capital investment - Very high degree of emphasis.** This, along with job creation, has been one of the two key policy objectives for many years. As noted earlier, there is continuing debate over the intrinsic merit of capital intensive projects, especially as they relate to job creation.

- **Encouraging particular industries - Low degree of emphasis.** Apart from special incentives targetted at high technology enterprises, the U.K.'s investment policy tends to be more region-focused than industry-focused. On a regional level, the policy is occasionally more industry specific (e.g. Scottish Enterprise's encouragement of high technology industries).

It is worth noting that the evidence on the ability of overseas investment to stimulate the development of local capabilities (e.g. R &D) is mixed, especially given that this has been a key feature of the government's policy. Munday (1990), for example, has studied the impact of Japanese investment in Wales in detail. He concludes that the Japanese have followed the four principles for inward investment proposed by the CBI in the early 1980s: high local content; net increase in jobs; high proportion of local manufacture should be exported; and the Japanese should not compete "unfairly" with their British counterparts (i.e. due to the financial assistance at startup). On the negative side, he points to aspects of the "branch plant" syndrome: real decision making power lies outside Wales, fluctuations in the parent country's economy reflect themselves in the Welsh economy, there are few research and development facilities in the Welsh plants, and - perhaps as a result - there are also limitations in the quality of employment that can be offered. Of these four, particularly worrying from a local capability building perspective is the lack of local R &D and parent companies' unwillingness to transfer managerial authority to the Welsh plants (a pre-requisite for building local management skill).

## 2.4 National policy instruments

Having discussed the overall objectives of U.K. investment policy in the previous section, I will now describe the broad types of policy instruments available and the degree of emphasis each has had in recent U.K. policy.

### 2.4.1 General framework

Vanhove and Klaasen (1986) have identified and described six broad types of policy instruments. These are the following:

- **Infrastructure aids.** Vanhove and Klaasen (1986) cite the 13 categories of regional infrastructure identified by D. Biehl (1986), including transportation, communications, energy supply, water supply, location (e.g. industrial sites), environment (e.g. waste treatment, water purification), education, health, special urban (e.g. fire protection, technological transfer agencies), sport and tourist facilities, social facilities (e.g. OAP homes, housing, creches), cultural facilities and natural endowment. Each of these has potential impact on plant location decisions.
- **Financial incentives.** Vanhove and Klaasen identify five types of regional financial incentives: capital grant, interest related subsidy, tax concession, depreciation allowance and labour related subsidy. Traditionally governments have paid great attention to this policy lever (see Yuill et al, 1980-, for a comprehensive description of European policy approaches).
- **Disincentives.** These measures seek to control the location of enterprise, e.g. by denying planning permission in congested areas.
- **Decentralisation of government offices.** By decentralising its offices, a government can provide regional benefits through local job creation.

- **Regional allocation of public investment and government orders.** By sharing its own procurement among the regions, a government can provide stimulus to depressed regions.

- **Regional development agencies.** By creating regional development agencies, a government can promote economic development in depressed areas. In particular, the agencies will be able to develop much better local knowledge than a purely centralized agency.

### 2.4.2 U.K. policy emphasis

These policy instruments have received different degrees of emphasis in recent U.K. regional policy (Figure 2.5).[7] The relative degree of emphasis is as follows:

- **Infrastructure aids- Low and declining importance.** In general, the U.K. has provided a reasonable level of infrastructure to potential investors, in such areas as transport, communications, etc. As noted earlier, the U.K. has maintained a factory building programme since World War II, although on a relatively small scale. This programme has become less important as a policy lever in recent years, as the government has increased its emphasis on self-finance. It could be argued that the government's privatization of power generation and,

[7] This summary draws on Vanhove and Klaasen (1986) and other sources cited in this chapter.

Figure 2.5:

# TYPES OF NATIONAL POLICY INSTRUMENTS

● = High Importance
○ = Low Importance

| Category of Investment | Importance in U.K. Policy | Rationale |
|---|---|---|
| Infrastructure aids | ◐ ➡ ◔ *(1980s onward)* | • Factory building programme in place since the Second World War (but relatively small scale)<br>• Emphasis in Thatcher era on self-finance for infrastructure projects (and public/private hybrids) |
| Financial incentives | ● | • Key instrument in U.K. regional policy<br>• Grants and selective loans emphasised over tax incentives<br>• Relatively recent shift from automatic grants to selective incentives (1985) |
| Disincentives | ◐ ➡ ○ *(1981 onward)* | • Industrial Development Certificate originally one of the few successful disincentive programmes in the EC<br>• Declined in importance 1960-1977<br>• Dropped in 1981 |
| Decentralization of government offices | ◕ | • Since the Second World War, a relatively high proportion of government jobs have been created in assisted areas |
| Regional allocation of public investment and government orders | ◐ | • Preference for orders given to firms in assisted areas, all other factors being equal<br>• Some formerly nationalised industries not allowed to expand in congested areas (e.g., British Steel) |
| Regional development agencies | ◐ | • Created in 1972-1979 era ("Expenditure growth and decline")<br>• Some policy administration devolved to local areas in Thatcher era (but source of conflict) |

more recently, rail, contributes to improving the U.K.'s infrastructure, although these are only loosely linked with regional policy.

- **Financial incentives - Very high importance.** As Figure 2.2 shows, this has been the key policy instrument in the U.K. for many years. A broad range of grants and loans are available; these are summarized and discussed in more detail below in Section 2.5.1.

- **Disincentives - Currently unimportant.** For many years until it was dropped in 1981, the government's Industrial Development Certificate programme acted as its key disincentive. It was uniquely effective relative to other similar types of measures available in European countries, although its importance did decline gradually over a long period of time. Twomey and Taylor (1985) studied the refusal rate for IDCs between 1960 and 1977. The rate rose to a peak refusal rate of 6% in 1961, and declined overall (with some volatility) until 1974. In 1974, the refusal rate fell to well below 1%, and remained at a low level until it was ultimately dropped in 1981.

- **Decentralisation of government offices - High importance.** Since the second world war, a relatively high proportion of jobs have been created in assisted areas. Some government offices have been devolved to the regions, such as the Department of Motor Vehicles in Swansea.

- **Regional allocation of public investment and government orders - Moderate importance.** There are cases of nationalized industries being required to locate in development areas (e.g. British Steel before privatisation was not allowed to build a new facility in the Southeast, but instead was required to build its facility in the depressed Teeside region). Some government purchasing programmes also give preference to contracts fulfilled by firms in depressed areas, all other factors being equal.

- **Regional development agencies - Moderate importance.** Regional development agencies were first created in the 1972-1979 era, and have persisted since. Both the Welsh Development Agency and Scottish Enterprise maintain a fairly strong local presence, independent of the central government, and therefore this lever has been fairly important to the U.K. in some parts of the country.

## 2.5 Types of economic incentives

This section draws some general observations about current investment incentives before describing two key incentives currently offered. It also describes the old Regional Employment Premium. Understanding these instruments is important to put the new instruments discussed in Chapter 6 in context.

### 2.5.1 Generalizations about current incentives

A wide range of investment incentives are available in the U.K. to investing firms (Figure 2.6).[8] These incentives can be broken into six broad areas: U.K. incentives, which are not industry specific; local authority incentives; industry incentives; R &D incentives; special incentives, which include export financing, free trade zones and science parks; and EU incentives. It is beyond the scope of this thesis to analyse each of these in detail, but five broad observations can be made.

- First, the **U.K. tends to favour grants over tax based incentives or direct labour subsidies.** This has probably contributed to simplicity of implementation, since fiscal measures tend to change frequently and direct labour subsidies can be complex and expensive to administer. Bachtler and Michie (1993) have noted that in the U.K., and broadly in Europe, the range of incentives has narrowed in recent years and has also become more grant focused. Also broadly in line with European trends has been the U.K.'s emphasis on more targeted assistance (i.e. automatic grants have been replaced with more selective ones).

- Second, the traditional support for direct investments in fixed assets has been complemented with "**promoting the business environment through softer, non-fixed asset aspects of company development such as consultancy**" (Bachtler and

[8]While Northern Ireland does have special investment incentives, these have not been separately identified and discussed.

# INVESTMENT INCENTIVES AVAILABLE

***Categories of Incentives***

- **UK Incentives**
  - Regional selective assistance (RSA)
    - Project grants
    - Exchange risk grants for coal/steel
  - Regional Enterprise Grants (Investment, Innovation)
  - British steel limited loans
  - British Coal Enterprise loans
  - Loans in rural areas
  - Urban renewal and land reclamation
    - City Grant
    - N. Ireland Urban Development Grant
    - Scotland - LEG-UP
    - Wales-Urban Investment Grant
  - Urban Programme
  - Urban Development Corporations
- **Local Authority Incentives**
  - Rural development schemes
  - Enterprise Zones
  - Land provision and site preparation
  - Construction and improvement grants/loans
  - Total or partial exemption from rates
  - Rent relief grant
  - Amenity provision grant
  - Relief grants towards borrowing costs
- **Industry Incentives**
  - Loan guarantee scheme (small business)
  - Advisory/consultancy services
    - Enterprise initiative
    - Training and Enterprise Councils (TECs)
- **R&D Incentives**
  - EU schemes (e.g., Eureka)
  - LINK
  - DTI assistance (e.g., SMART, SPUR, DEMOS)
- **Special Incentives**
  - Science parks
  - Rural development schemes
  - Tourism promotion
  - Free trade zones
  - Export incentives
    - Export Credits Guarantee Department
    - British Overseas Trade Board
    - Tax incentives
- **EU Incentives**
  - European coal and steel
  - Community conversion loans
  - European investment bank loans

Michie, 1993). This represents a fairly significant change in the mindset of development agencies.

- Third, there are **very few incentives given to particular industries.** This is probably wise, given Western Economies' poor performance in implementing industrial policy. Some regional agencies, such as Scottish Enterprise, have experimented more aggressively with industrial policy-like initiatives.

- Fourth, there is **no discrimination in investment assistance between overseas investment and local investment.** Virtually all of the investment incentives are "origin blind", i.e. are available equally to domestic and overseas investors. This provides a "level playing field", but may reduce the government's flexibility in attracting particularly desirous inward investment.

- Fifth, **local authorities in England, Scotland and Wales have considerable scope to influence investment at a local level.** This is reflected by the myriad of local incentives available (e.g. land provision and preparation, rent relief grants, relief grants towards borrowing costs).

One interesting aspect of Figure 2.6 is the sheer range and diversity of different types of incentives. This is particularly striking when one considers that these incentives are in place in a government that is strongly committed to the operation of a free market. This apparent inconsistency probably reflects the difficulty of resolving some of the long standing regional disparities in the U.K. (as noted in Section 2.2).

### 2.5.2 Discussion of specific current policy Instruments

This section discusses two specific instruments in more detail: Regional Selective Assistance and national investment incentives. The section relies upon material from Price Waterhouse (1994, 1995) and the Invest in Britain Bureau (1996), among other sources.

#### Regional selective assistance

The major policy instrument for regional development is Regional Selective Assistance (RSA), which consists of two types: project grants and exchange risk guarantees. The RSA grant is a discretionary and negotiable grant available for both manufacturing and service sector projects. Projects must require capital expenditure and create or safeguard employment in Assisted Areas (i.e. Development Areas or Intermediate Areas). Importantly, assistance is provided only to firms where the investment would not have been made anyway. A number of industries are subject to EU restrictions (e.g. iron and steel, shipbuilding). Payments are typically made in three separate tranches, and the DTI works to determine the minimum level of subsidy required to encourage a company to invest. A number of costs are eligible for assistance, including land purchase, site preparation and buildings, plant and machinery, and some other costs (e.g. patent rights, installation and re-installation of machinery). Importantly, relocation projects are not normally eligible unless there is a net increase in jobs. This continues the government's long-standing de-emphasis on migration and mobility policies. Most regional DTI offices can approve grants up to £2 million, although they generally involve the London office in awarding grants over £1 million.

The second type of grant is the exchange risk guarantee. This grant is primarily directed at offsetting the risk undertaken when a company accepts a loan in a local currency from the European Coal and Steel Community (ECSC). This incentive is clearly highly specialized, and not of great national importance.

Vanhove and Klaasen (1986) have identified five well known drawbacks to grant based systems. First, the schemes tend to expensive. Second, the financial responsibility of the government agencies is greater than with an interest rate rebate system. Third, grants can lead to inflationary pressures in other regions. Fourth, receiving grants can feel somewhat humiliating to local regions. Lastly, and most importantly, grants tend to bias investment towards capital intensive projects. Nonetheless, they remain an important policy instrument in the U.K..

### National investment incentives

A second important type of regional policy instrument is national investment incentives. These consist primarily of tax relief on investment expenditure. They include 100% first year allowance for the costs of buildings in enterprise zones and scientific research costs. There are also general allowances for plant and machinery (25%) and industrial buildings (4% flat rate). In 1995, the 4% flat rate was extended to roads. Price Waterhouse notes that although there are few tax incentives per se, there are three general factors that make the U.K. fiscally attractive: relatively low corporate taxes, an extensive network of double tax treaties which provide exemption or relief from U.K. withholding tax on interest and royalties, and no withholding tax on dividends paid by U.K. resident companies.

The government expenditure for these incentives can be substantial. A 1982 National Economic Development Organization study described in Brech and Sharp (1984) estimated that the total of these allowances was £5,300 million for 1980/1981 (domestic and overseas investments).

### 2.5.3 Regional Employment Premium

One policy instrument of importance to this research is the Regional Employment Premium (REP), in that it creates a precedent for direct government intervention in labour rates. Yuill et al (1980) have reviewed the history of this instrument, and this brief discussion is based upon their analysis and further discussion in Vanhove and Klaasen (1986). The REP was begun in 1967 by the incumbent Labour government, and its purpose was to subsidise labour costs directly in Development Areas and Special

Development areas. It was felt that the REP had two main benefits. First, it gave poorer regions an additional labour cost advantage to offset other potentially higher costs (e.g. transport). Second, it avoided the traditional capital orientation of regional incentives. Vanhove and Klaasen identify five reasons for its introduction: it implied no discrimination against existing firms; it gave special encouragement to labour intensive types of industry; it cut regional production costs and so had the positive effects of a regional devaluation without the negative ones (no higher import prices); it minimised the spreading of effects to other regions; and it incorporated an income transfer from rich to poor regions.

In operation, subsidies were paid directly to assisted companies based upon the employee base. Different levels of subsidy were paid for full time men, women/boys, and girls. It was intended to have a significant impact on assisted companies' labour costs; at the time of its introduction, the REP was estimated to account for between 7 and 8 percent of assisted firms' labour cost.

In 1970, a new Conservative Government took office, and announced that it would phase out the program in line with its objective to reduce government intervention. The programme had become very expensive to implement, given its non-selective implementation. The following Labour government announced a new set of subsidies in July, 1976 which cut the overall level of assistance and reduced the disparity of support between the sexes. Before these new levels could be put into practice, however, the REP was abolished completely in December, 1976.

While no longer in place, the REP is relevant to this research because the implementation of the volatility minimisation instrument described later incorporates some similar elements (although in this research, the **volatility** of labour cost is subsidised, not the absolute cost level). As will be shown later, the volatility minimisation instrument preserves many of the advantages of direct intervention in labour costs, but at minimal cost.

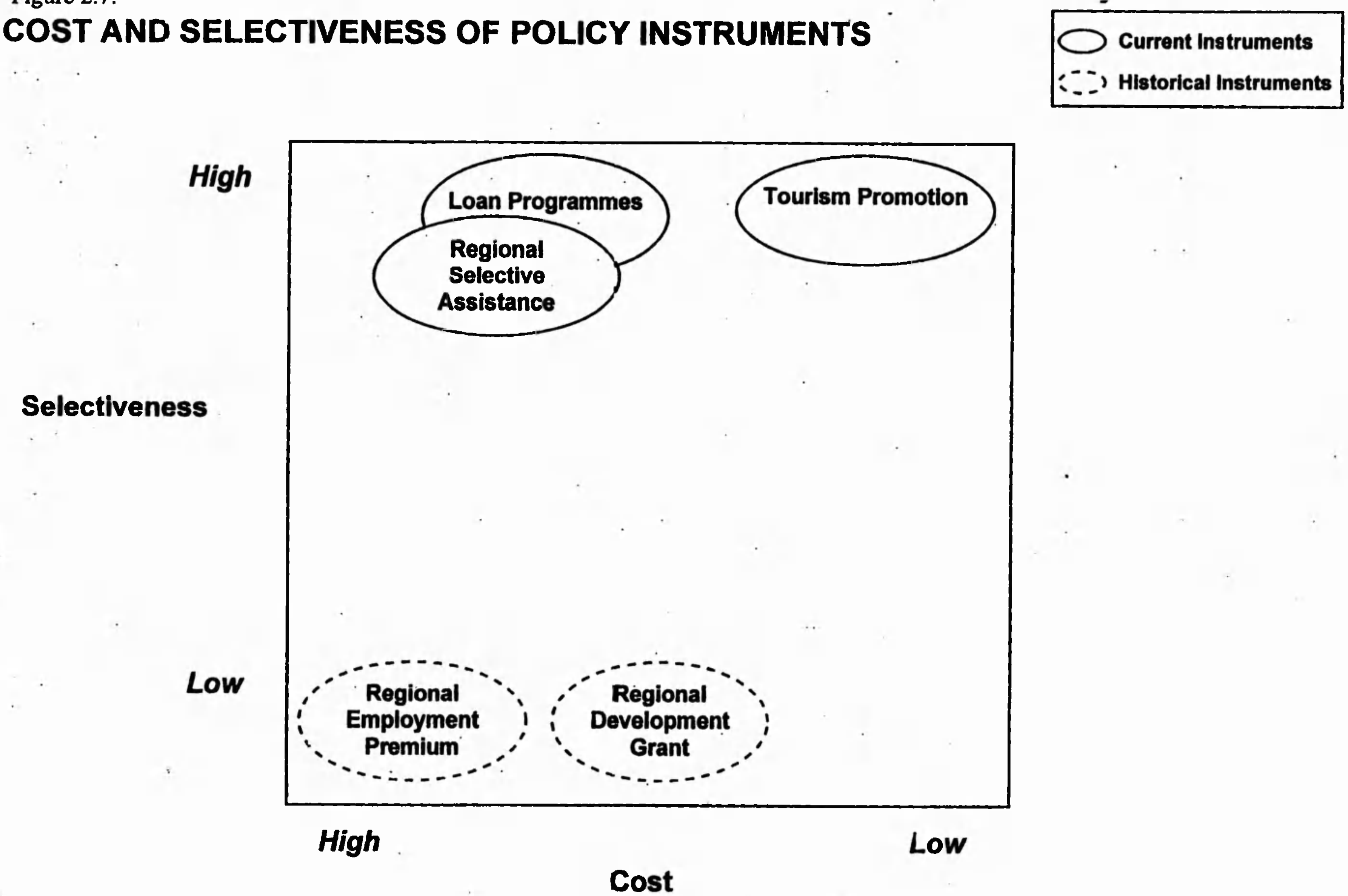
## 2.6 Attractiveness of individual instruments

The instruments described in Section 2.5 vary significantly in their total cost and selectiveness (See Figure 2.7 for an analysis of selected instruments). This matrix will be used later in this thesis to compare the recommended new policy instrument with current and historical policy instruments. The ideal policy instrument would of course be low cost. The issue of selectiveness is more complex. Ideally, the instrument would be sufficiently flexible to be applied selectively when required to meet particular government objectives. However a low cost policy instrument need not necessarily be selectively deployed.

Both the Regional Employment Premium and the Regional Development Grant are in the high cost/low degree of selectiveness quadrant. Both were ultimately dropped over concerns over their total cost to implement.

Figure 2.7:

**COST AND SELECTIVENESS OF POLICY INSTRUMENTS**



Regional Selective Assistance and Loan Programmes are far more selective, but they are also relatively high cost. Nonetheless, they are both likely to have a long term role in regional policy. Tourism promotion and Exchange rate guarantees to the Steel industry are both highly selective, but relatively low cost. Their extreme focus tends to diminish their overall significance in regional policy, however. The ideal location in the matrix for a policy instrument would be on the low end of the cost axis. It would also need to be broad-based (i.e. applicable to many industries). The instrument could range anywhere on the selectiveness dimension. As will be seen in Section 6.2.4, the most significant proposed new policy instrument fits this criterion.

## 2.7 Prevention of excess competition for investment

This section provides a brief discussion of one final important topic in regional policy: preventing excess competition for investment. While a full treatment of this topic is beyond the scope of this thesis, it is important to provide a brief introduction to it so that the implications of the final recommendations on this area may be assessed.

Guisinger (1985), as cited in Dicken and Tickell (1992), "drew the analogy between the competitive behaviour of business enterprises seeking to increase market share for their products and the competitive behavior of countries seeking to capture an increasing share of foreign investment projects." Guisinger then extended this analogy to the sub-national scale (e.g. in the promotional behaviour of RDOs[9]). This analogy is significant in understanding the behaviour of both countries and local regions. As Porter (1980) has written, one of the five determinants of the attractiveness of an industry is the degree of company rivalry. This can range from the extreme (e.g. aggressive price cutting in the ship building industry) to informal cartels that keep prices high. This concept of rivalry applies equally to development agencies. One would expect variations in the degree of aggressiveness of inward promotion, and indeed this is observed. Faced with this reality, national and supra-national governments have attempted to place limits on the degree of inward investment promotion.

Although the issue of limiting investment promotion will not be discussed in detail in this research, it is worth briefly describing the current European model, in order to ensure that the new instruments proposed in Chapter 6 are consistent with current EC practice. Historically, the EC has sought to minimise destructive competition for investment by establishing coordination solution aid ceilings. In 1979, for example, the maximum aid for the U.K. (excluding N. Ireland) as a net-grant-equivalent percentage of initial investment was 30%, or a ceiling of 5500 European units of account (cited in Yuill et al, 1980). For Northern Ireland, the amount was a staggering 75% of net-grant-equivalent or 13,000 European Units of Account. Even given these constraints, local areas are still able to provide

[9] Regional Development Organisations.

aggressive additional incentives, such as site preparation.

## 2.8 Potential application of option techniques to national policy instruments

Option pricing techniques are applicable to all six types of policy instruments described in Figure 2.5. However, it is beyond the scope of this analysis to apply these techniques to all these instruments. Instead, the focus of the remaining analysis will be to apply option pricing techniques to financial incentives. To do this requires two basic types of analysis. First, the equations to be described in Chapter 4 may be used to identify a new set of instruments that encourage investment by minimising uncertainty. Second, the impact of Poisson events may be incorporated into the investment decision. Poisson events refer to single, "step changes", e.g., the possibility of a change in tax rate. These will be discussed in greater detail in Chapter 4.

Figure 2.8 describes how option pricing techniques may also be applied to the remaining five types of policy levers referred to in Section 2.4.2 above. Note that in every case, Poisson events may be used to model the impact of single events, such as the government's re-imposition of a disincentive programme that would block the proposed investment (the possibility of analysing multiple uncertain events is discussed briefly below). The

Figure 2.8:

## SCOPE FOR APPLICATION OF OPTION THEORY

Focus of research

| Category of Investment | Application of option theory approach |
|---|---|
| Infrastructure aids | • Use Poisson analysis approach to incorporate impact of potential infrastructure programs (e.g., road building) |
| Financial incentives | • Develop new tools based on impact of uncertainty<br>• Use Poisson analysis to model impact of addition or removal of particular incentives |
| Disincentives | • Apply Poisson analysis (but disincentives no longer important policy lever) |
| Decentralization of government offices | • Apply Poisson analysis (but difficult to estimate dollar impact) |
| Regional allocation of public investment and government orders | • As for decentralisation of government offices |
| Regional development agencies | • Poisson analysis possible, but difficult to estimate potential direct economic impact |

***Higher Impact Opportunities***

***Lower Impact Opportunities***

complete set of six policy levers can be categorised into areas of higher or lower potential for application of option theory:

- There are **higher impact opportunities** to apply this thinking to financial incentives and infrastructure aids. The most attractive area for application of option theory is the one considered in the remainder of this thesis: financial incentives. Analysing this area allows consideration of two types of uncertainty in the investment decision (i.e. both volatility and Poisson events). It would also be possible to model potential infrastructure building programmes with Poisson events (e.g. road building), but these will not be considered further.

- The remaining four levers are **lower impact** opportunities. Poisson event modeling could be used for three additional levers (i.e. decentralisation of government offices, regional allocation of public investment and government orders, regional development agencies), but these will not be considered further in this analysis. Disincentives are no longer an important policy lever, and so option theory would probably have limited practical application.

Some academic work is also being conducted that models the potential impact of **multiple** events, for example the possibility of a tax credit being instated and then withdrawn at a later date. Metcalf and Hassett (1993, as described in Dixit and Pindyck, 1994), for example, have modeled the impact of tax credits on investment decision making. They analysed investment where there is a probability $\lambda_1$ of implementing a tax credit when it is not already in place, and a probability $\lambda_0$ of withdrawing it if it is in place. They found that "uncertainty about the enactment of stimulus policies is likely to have a very detrimental effect on investment. In fact, if a government wishes to accelerate investment, the best thing it can do is to enact a tax credit right away, threaten to remove it soon, and swear never to restore it (high $\lambda_0$ and low $\lambda_1$). The credibility of such a policy is, of course, open to doubt." More detailed analysis such as this could be applied to all six policy levers.

## 2.9 Summary

This chapter provides an analysis of the government's regional policy objectives and approach to stimulating inward investment. As such, it provides the overall context within which companies make investment decisions. In particular, it provides insight into five important areas of U.K. regional policy:

- **General regional policy objectives.** Based on analysis of five eras of regional policy, several themes emerge. These include the continuing need for regional intervention, the long-standing belief by both parties that inward investment should be encouraged and the government's willingness to experiment with innovative approaches.

- **Investment policy objectives.** Based on academic research, six types of investment policy objectives were identified and assessed for their relative importance. Primary job creation and capital investment were the two most important objectives, followed by stimulus for domestic industry, secondary job creation, encouraging particular industries and encouraging the eventual transfer of other corporate functions.

- **Investment policy instrument emphasis.** In the area of policy instrument emphasis to encourage investment, the government has given primary emphasis to financial incentives, followed by decentralisation of government offices, creation of regional development agencies, regional allocation of public investment and government orders, and infrastructure aids. Disincentives have not been used since 1981 as a policy lever.

- **Approach to investment incentives.** While there are a plethora of investment incentives available, some broad generalisations may be drawn. These include emphasis of grants over tax incentives or labour subsidies, introduction of broader support to businesses (e.g. provision of consultancy services), limited application of industrial policy, and equal treatment of inward investment and domestic investment. It was noted that local authorities have a significant role in influencing local investment decision making. Some discussion was also included of the cost and selectivity of particular incentives. It was concluded that the ideal instrument would be low cost to administer, but leave some flexibility in how selectively the government chose to adopt it.

- **Avoiding excess competition for investment.** This chapter discussed briefly the potentially destructive effect of excess competition for investment, and noted the important role of EC legislation. The impact of the proposed volatility-minimisation instrument on competition for investment will be described further in Chapter 7.

Each of these areas will be discussed further in Chapter 7 to assess the coherence of the recommendations with recent themes in regional policy and investment policy. This later chapter will also draw upon the description of the Regional Employment Premium to discuss similarities and differences between the proposed new volatility minimisation instrument and the old REP.

Moving forward, Chapter 3 discusses key issues in plant location decision making from the perspective of the investing company. Chapters 4, 5 and 6 then describe an analytical approach used to identify and assess potential policy instruments to encourage inward investment.

# Chapter 3

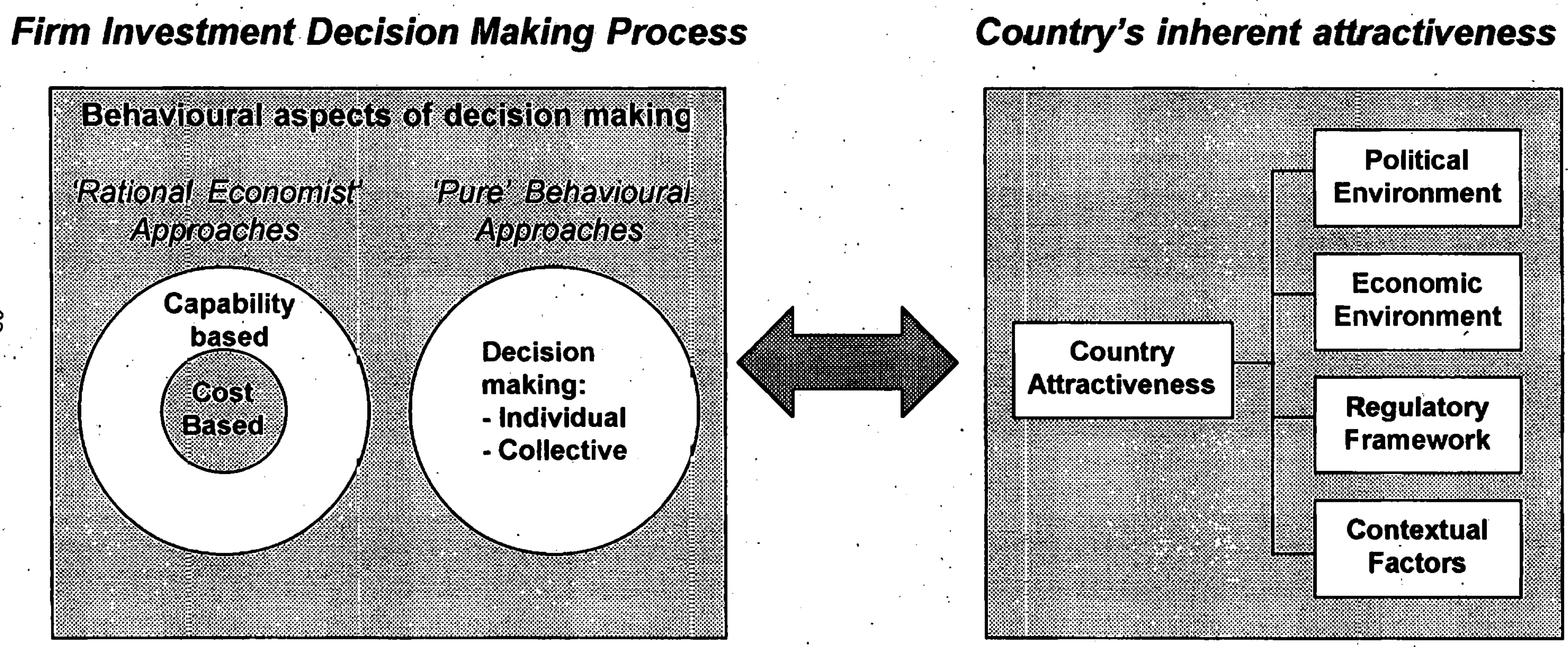
# The Overseas Plant Location Decision

This chapter explores two key aspects of an overseas plant location decision: how companies make investment decisions and how they assess the inherent attractiveness of a particular location. This analysis therefore summarizes important aspects of the plant location decision from the **corporate** investor's side (the previous Chapter was concerned with how national and regional policy makers seek to attract inward investment).

Figure 3.1 shows a simple framework that captures these two aspects of the plant location decision and their interaction. The left side of the framework shows different schools of thought regarding the location decision, both analytical (i.e. "rational economist") and "pure" behavioural (these are the circles within the box). Cost based approaches are shown as a subset of capability based approaches for reasons that will be discussed in

Figure 3.1:

# THE OVERSEAS PLANT LOCATION INVESTMENT DECISION



Section 3.1.2 below. Since all decision making needs to be considered in light of behavioural factors, the small circles are shown within a larger box covering all behavioural aspects. The right side of the framework is a placeholder used for the detailed framework to assess a country's attractiveness as discussed in Section 3.2 below. Following general exposition of the framework, the U.K.'s attractiveness is assessed in Section 3.3 using the framework.

## 3.1 Firm investment decision making processes

This section discusses how firms make investment decisions. It begins with some theoretical background on why companies invest overseas and then describes investment decisions based upon three different approaches: cost based, capability based, and behavioural.

### 3.1.1 Rationale for foreign direct investment

The traditional economist view of foreign direct investment is that it arises because of imperfections in product and factor markets (see for example, Collis and Noon, 1994). This theoretical rationale for investment leads naturally to evaluating potential plant location opportunities on a primarily cost-driven basis. As Collis and Noon have written "The decision to produce abroad, rather than to export or license, arises when economic rent obtained from possessing these advantages can be increased by production in a foreign location. Because of the existence of transaction costs in marketing such advantages (e.g. taxes paid on market transactions) there is an incentive for TNCs[1] to internalize transactions within the firm rather than through the market. In choosing where to produce, TNCs consider locational factors such as relative labour costs and regional financial incentives." As will be seen later in the chapter, cost is only a subset, albeit an important one, of the factors that should be considered when a company makes an investment decision.

### 3.1.2 Cost based approaches

A wide variety of differing approaches have been developed to assess the costs and benefits of a plant location decision. For the purposes here, these approaches will be grouped under the heading of the "rational economist" approach to plant location decision making. [2]

Approaches to this problem tend to begin with abstract models of firms and customers, and include different types and complexities of cost factors (e.g. labour, land, raw materials, transport costs, energy, insurance, costs of

[1]TNC is an acronym for "transnational corporation"

[2]Note that this is somewhat different than the definition that is sometimes used by economists. Baumol and Blinder (1985), for example, use the term "rational" to apply to the means, not the ends. In other words, their definition asks whether the decision making behaviour will fulfil the desired objective, whether or not that objective is rational. In this thesis, it is more appropriate to focus on whether the plant location objective is appropriate, i.e. maximizes the financial and other benefits to the investing company.

decision making). Hilhorst (1990) and Chisholm (1990) have described some of the early literature in this area. Weber (1929) identified transport cost minimization as a key input into decisions and therefore regional organisation. Hoover (1948) analysed transport costs, and found that transport cost does not increase proportionately with distance (e.g. due to fixed terminal costs such as storage, on-loading and off-loading). As a result, transport costs are less important in the aggregate as distance increases and therefore intermediate locations are less attractive than they would otherwise be. Isard (1956) studied transport and production costs in different locations, and concluded that a firm will locate where increases in production costs just offset decreases in transport cost. These types of considerations are now routinely incorporated into company investment decisions.

Purely cost based decisions often suffer from a key weakness: they are frequently conduced on a static basis, i.e. without incorporating the fact that factor costs tend to increase over time (Bartmess and Cerny, 1993). Ohmae (1985) refers to this phenomenon as the "expense of cheap labor". MacCormack et al (1994) remark that "companies continuing to focus on direct labor cost savings may find transitory advantages, but eventually, as has happened in Korea, cost pressures will wipe out such advantages." Unless these expected increases over time are taken into account the results are likely to be disappointing (Bartmess and Cerny, 1993).

Purely cost based approaches also ignore a number of other key aspects of the overseas investment decision. Markides and Berg (1988) have summarized some of these. They include the risks of being subject to local government pressures (e.g. to increase domestic content), alienating key domestic stakeholders (e.g. unions), fleeting factor cost advantages (e.g. due to labour cost increases as noted above), weakened corporate capabilities from "hollowing out" the company (e.g. losing design and manufacturing skills) and discovering higher than expected operating costs in the local region. The actual transfer of technology can also have a major impact on the economics of an overseas plant investment or plant relocation. Galbraith (1990) has studied the effect of transferring core manufacturing technologies in high technology businesses, and has discovered that managers, engineers and operators almost unanimously underestimated the complexity of the transfer. The transfers usually resulted in a short term loss of productivity in the receiving plant of 9 months to reach pre-transfer levels of productivity. Taking advantage of a period of co-production reduced the time to 5.3 months, but was still significant. Delays of this scale can have a significant impact on the economies of plant locations and relocations if they are not accounted for correctly.

### 3.1.3 Capability based

Purely cost based approaches implicitly assume that the location of a plant has little or no impact on a company's overall competitiveness or internal operations, beyond the effect of the cost of operations on the total cost structure. Recent work (Bartmess and Cerny, 1993) has begun to note that the physical locations of functions within a company can support or undermine its capabilities and therefore its ability to compete. Other work has noted that the local infrastructure can have a significant impact on a company's competencies.[3] Rosenfield et al in Bartmess (1994) has noted that in making a investment decision, a company's competencies should dictate workforce and infrastructure requirements and ultimately the site location. MacCormack et al (1994) make a similar point by dividing infrastructure into "hard" requirements (e.g. communication and transport systems) and "soft" requirements (e.g. workforce education levels, suppliers with specific technical know-how). They note that these soft factors are often overlooked in traditional location algorithms but can be the most important sources of competitive advantage.

Wheelwright in Bartmess (1994) reinforces the importance of the capability/competence approach. He notes that even in the narrowest plant location decision - the facility/site question (i.e. where to locate a single plant) - there are three types of approach, only one of which relies upon cost as its primary source of competitive advantage. The first type of facility is found in companies requiring high volume/low cost, and is typically located offshore in low labor cost areas. These plants are continually evaluated on their ability to provide the lowest possible costs

[3] While there are some technical differences between competencies and capabilities, both terms relate to a company's ability to sustain competitive advantage. See Prahalad and Hamel (1990) for a good introduction to corporate competencies.

(and are therefore implicitly prepared to shut down or relocate as required). The second type of facility is found in companies which rely upon intense interaction with their customers (e.g. metal can and plastic bottle plants). The third facility type can be found in companies that compete primarily on product design and features in a rapidly changing technological environment. As Wheelwright notes, these plants rely upon close ties between development engineering and manufacturing. The analysis in Bartmess and Cerny (1993) would suggest that for this type of company, making a plant location decision without considering the interaction between manufacturing and development engineering could have a significant negative effect on the company's competitiveness.

While in principle a cost implication may be assigned to nearly all of these competency oriented factors, this is not always done in practice. As MacCormack et al (1994) note, "Decisions are often based purely on quantitative analyses that trade off transfer costs, scale economies, and other cost-based variables. This practice, however, can lead to suboptimal results, as decision makers tend to focus only on factors that are *easily*[4] quantifiable. Important qualitative issues are frequently neglected or used only to temper results." For the purpose of this thesis, it will be assumed that the impact of location decisions on a company's capabilities and competencies can be quantified, at least approximately. The policy instruments described in Chapter 6 may then be applied to the broadly defined overseas investment decision, including both traditional cost-based

[4]Original emphasis

elements and more capability oriented ones.

### 3.1.4 "Pure" behavioural approaches

A second approach to analysing overseas investment decisions argues that decisions are not made primarily on a rational, analytically oriented basis, but are often made primarily on the basis of behavioural factors. The author's experience in working with major multinationals in the U.K., U.S. and Europe has found instances of decision making that are at odds with rational, fact-based economic decision making. I have identified five specific examples below, disguised for confidentiality, each of which shows a corporate decision that was made primarily on the basis of behavioural (i.e. non-economic) factors (see Appendix B for summary of interview locations and dates).[5]

#### Case examples

The five specific case examples are as follows:

- A **global pharmaceutical company** invested several hundred million pounds in a research facility based upon a one page proposal to the board. The company's cash flow was embarrassingly strong, and the research facility seemed an attractive way to build relationships with the government. In addition, the company had a

[5] In disguising the case examples, I have adjusted specific details so that the particular company is not readily identifiable. The essential outline of the example has been left unaltered, however.

strongly research-based culture that supported such a move. No detailed financial analysis of its potential costs and benefits was conducted prior to board approval. The company subsequently merged, and thereby gained access to high quality research facilities. In the end, it closed some of the research space, almost certainly without having achieved an appropriate level of return.

- **A light manufacturing company** planned to invest in an Asian operation, based upon the manager's instincts that costs would be lower there. However, the manager had other motivations as well. The plant was located in a remote location, and an overseas location provided the opportunity to justify lavish business travel to exotic locations. Actual analysis of the proposed investment showed that it had at best a poor return. Nonetheless, the manager was determined to invest there for the reasons described above.

- **A global consumer goods company** was undertaking a review of its head office costs. It was discovered that the company was paying drivers for its board of directors at double the local market rate. In addition, the drivers were so underutilized that the company had to construct a billiards room in the basement of the head office, at high expense given the cost per square foot of the office space. By any pure economic analysis, there was substantial opportunity to reduce cost in this area. However, the drivers learned of the cost reduction plan, and lobbied the wives of the directors.[6] The senior executive running the

[6]There were no female board directors

cost reduction programme was reluctant to challenge the board on the issue, and as a result, the plan to reduce costs was dropped.

- A **global insurance brokerage** spent a large percentage of an entire year's profits on a several year renovation programme for its listed head office, during a period of time when the company's operating results were very poor. The renovation was cosmetic, not structural, and was based upon a vague sense that the company needed a quality office building to impress clients. The share price, however, was already low, and the lavish spending programme did little to reassure the financial markets that the company was serious about reversing the poor operating results. In fact, the share price continued to decline, in part due to the company's unwillingness to tackle costs seriously.

- A **global fragrance manufacturer** was scheduled to submit a bid in the U.S. for a very important commission (approximately 30 % of total revenue for the U.S. operation). As is typical in the industry, it created an internal competition among its perfumers (i.e. the individuals who create fragrances by blending together different ingredients), involving perfumers in both Europe and the U.S. The final selection process to choose the submitted fragrance, however, was heavily biased in favour of the U.S. perfumer submission, regardless of the quality of the European submissions. As a result, the company lost the benefit of its European expertise in a critical bid.

Each of these case examples describes an example of poor corporate decision making that ultimately cost the company resources, either directly of indirectly. The failures in the decision making process that led to these poor decisions can be divided into two types: failures from individual decision making, and failures from collective decision making.

### Individual decision making

In the case of the light manufacturing company, the failure to make a rational economic decision depended mostly upon one individual's decision making. Although his decision was nominally subject to corporate review, the review was superficial. In fact, he had been delegated sufficient authority to make the decision himself, and was unlikely ever to be subject to any senior level management scrutiny over the decision.

### Collective decision making

The other examples shown above describe failures in collective decision making, i.e. in how organizations actually make decisions when multiple individuals are involved. Kotter (1985) has built up a substantial theory on leadership and decision making. He has argued that the workforce is growing both more diverse (e.g. different nationalities, backgrounds, etc.) and more interdependent (e.g. more coordination required to make decisions). He writes that these factors often lead to conflict, which can either be handled well or poorly. If the conflict is handled well, the organization gains the benefit of more original thinking, leading to "more creative solutions to problems and more innovative products and services." If the conflict is handled poorly, the organization gets locked into "bureaucratic infighting, parochial politics and destructive power struggles."

The case examples above demonstrate the potential impact on a company when complex decisions are made poorly. In the case of the pharmaceutical and light manufacturing companies, limited internal politics emerged, but the company lost the benefit of optimal decision making. In the case of the consumer goods company, some bureaucratic infighting did emerge over the proper approach to the drivers' pay, and more intense struggles emerged in the office renovation of the insurance brokerage. In the case of the global fragrance manufacturer, the company behaved exactly as Kotter predicted: the organization was locked in a bitter dispute that blunted its opportunities for competitive success. The struggles that emerged led to "higher costs and enhanced organizational frustration," both of which are predicted by Kotter's analysis.

For my purposes, behavioural approaches will not be considered further. Plant location decisions should ultimately be made upon rational application of cost and capability oriented factors. While behavioural factors certainly play a role, they should not be allowed to detract from the underlying economics.

## 3.2 Assessing a country's inherent attractiveness for investment

This section describes a general framework that can be used to identify the inherent attractiveness of a country for overseas investors and then applies it to the U.K. By using this framework, it is possible to understand the "outside in" attractiveness of investment opportunities in the U.K.

### 3.2.1 General framework

As Kogut (1985) has stated, "Global strategies...rest on the interplay between the competitive advantage of firms and the comparative advantage[7] of countries." Manufacturing investment is a key aspect of any global strategy, and therefore both firm competitive advantage and country comparative advantage are required for successful global strategies. This section describes a framework developed by the author that can be used to assess the comparative advantage (i.e. attractiveness) of a given country for plant investment.

As a first step in assessing a country's attractiveness for investment, it is possible to draw up a comprehensive list of all factors that should be included in a plant location analysis. A recent example is the Price Waterhouse approach as described in the Financial Times Survey (reported by Cassell, 1993). These factors included ones such as the existence of a

[7] e.g. comparative abundance of skilled workers

stable political situation in the country receiving the investment, reasonable labour costs, reliability of power supply, and availability of skilled workers. Surprisingly, availability and quality of telephone, fax and data lines was ranked first, but probably reflected a strong participation of "knowledge intensive" firms in the survey.

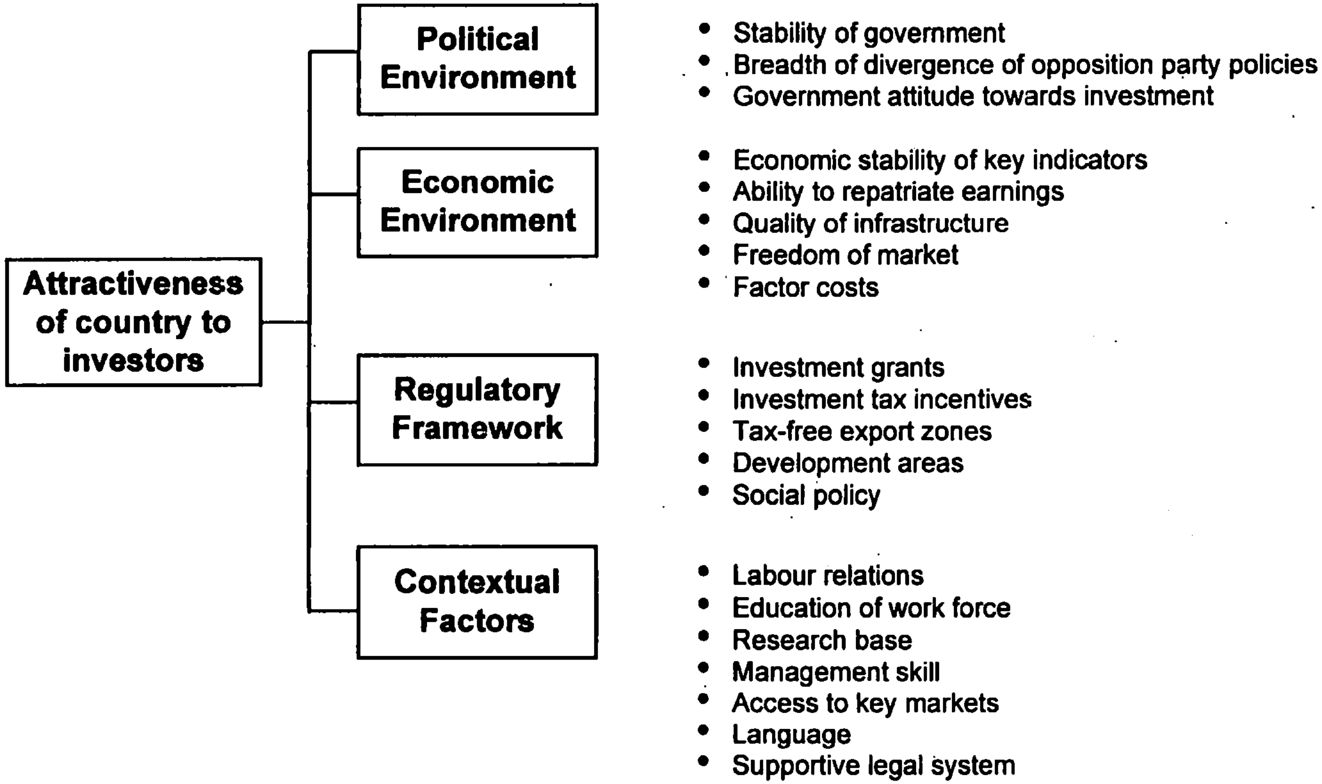
Having established this list of factors, it is then possible to develop a simple ranking system that can be used to assess locations both across different countries and across different potential sites within a given country (e.g., the Euromoney risk assessment method, Euromoney, 1988). My approach has been to take a fairly comprehensive set of factors and group them together into four logical categories (See Figure 3.2). This approach enables analysis and assessment at three levels: individual location aspects (e.g. labour relations), broad attributes of a location (e.g. regulatory environment) and overall assessment.

The four specific elements of a country attractiveness assessment are as follows:

- **Political environment.** A government's political stability is a major influence in a company's decision to invest. This factor has been instrumental in building the economies of a number of developing or newly industrialised Asian economies. Ironically, a stable democracy in the political sense (i.e. two or more robust political parties) may significantly undermine a country's attractiveness because it introduces policy uncertainty. This is particularly true when the

Figure 3.2:

## ASSESSING A COUNTRY'S ATTRACTIVENESS FOR INVESTMENT



parties are relatively divergent in economic policy (e.g. France). Countries where there is significant risk of a military intervention or political collapse are naturally the least attractive.

- **Economic environment**. A country's economic strength is a critical aspect of its attractiveness. High inflation or a weak currency can undermine otherwise attractive country characteristics, as the Brazilian market has demonstrated.

- **Regulatory framework**. Given these underlying factors, a country's attractiveness can be enhanced or undermined by its regulatory framework for investment. India, for example, has many attractive characteristics - such as a low cost, skilled workforce - but for years has undermined these features with a highly restrictive and bureaucratic approach to regulating foreign investment.

- **Contextual factors**. Finally, there are a whole collection of contextual factors that can influence a country's attractiveness. These include the skill and flexibility of the labour force, the skill and experience of management, and a country's access to key markets (e.g. through trading blocs). Even the local language can have significant impact. As Strange (1995) has noted, many Japanese companies have found the U.K. an attractive market relative to other European countries because their managers already speak English. In fact, a recent survey (JETRO 1992) found that this was the single most important criterion for selecting the U.K. among potential

European locations.

Having laid out this framework, it is important to note that there is an additional aspect that must be considered: the awareness of potential investors of these elements. Unless this awareness exists, company decision makers may not even consider a given location, no matter how attractive its intrinsic characteristics.[8] This factor was highlighted in a recent (January, 1996) discussion I participated in with executives from the Australian Manufacturing Council. They felt strongly that one of their most important activities was publicising the intrinsic strength of the Australian environment relative to many Asian countries. Chisholm (1990) makes the same point by identifying promotional information as one of three primary ways to stimulate inward investment (his other two are initial, one off assistance and assistance to companies that have already set up and are in business)

### 3.2.2 Assessment of U.K. attractiveness

Having laid out the elements of a country's attractiveness to outside investors, we can now assess the attractiveness of the U.K., from the

[8]As Foust and Mallory (1993) have documented, companies and regional policy makers go to great lengths to build awareness of their company and region, respectively, with potential investors. For example, NationsBank in Atlanta has hired models to impersonate characters from *Gone with the Wind* as a draw for potential Japanese investors. Tennessee recruiters take potential Japanese investors to the Grand Ole Opry in Nashville, and give dulcimers as gifts.

perspective of both cost and capability based criteria.

**Cost based aspects**

Figure 3.3 summarizes the relative attractiveness of the U.K. to outside investors. This analysis is based upon work by Banham (1994), Strange (1995) and others.

- **Political environment**. The U.K. political environment as affects investment is quite strong. There is a long tradition of stable parliamentary democracy, and both parties strongly support inward investment. Clouding this attractive picture is a traditional policy divergence between the Conservative and Labour governments in political, social and regulatory aspects of investment policy. It is important to note that this divergence creates significant uncertainties over the direction of future policies, which has a strongly negative impact on investment (see Section 6.3.3). This divergence has been closing in recent years, however, which should make the political environment increasingly attractive to investors.

- **Economic environment**. The U.K.'s economic environment is moderately strong at present (e.g. reasonable economic growth, relatively low inflation, stable recovery in the housing market and supporting industries), although there have been significant periods of weakness in the past (e.g. the IMF intervention to protect the pound in the 1970s). The U.K. has traditionally been a relatively high inflation environment (although inflation has been much lower in

Figure 3.3:

## ASSESSING U.K.'s ATTRACTIVENESS FOR INVESTMENT

● Attractive
○ Not attractive

**Attractiveness of country to investors**

| | U.K. assessment | | Rationale |
|---|---|---|---|
| **Political Environment** | • Stability of government | ● | — Robust, 2-party democracy (niche third party) |
| | • Breadth of divergence of opposition party policies | ◑ | — Traditionally wide divergence between Labour and Tory parties; narrowing under Blair's leadership |
| | • Government attitude towards investment | ● | — Both parties strongly support foreign investment (Labour more so if tied to job creation) |
| **Economic Environment** | • Economic stability of key indicators | ◑ | — Moderately strong economy; tendency towards high inflation and highly volatile pound/dollar exchange rate |
| | • Ability to repatriate earnings | ● | — No limits on repatriation of earnings |
| | • Quality of infrastructure | ◑ | — Infrastructure in need of significant investment |
| | • Freedom of market | ◑ | — Current government very free market-oriented; opposition more moderate |
| | • Access to key markets | ● | — Strong ties with Europe (via E.C.) and U.S. |
| | • Factor costs | ◑ | — Attractive factor costs in some areas (e.g., wage rates) |
| **Regulatory Framework** | • Investment grants | ◑ | — Primary tool for stimulating investments |
| | • Investment tax incentives | ◔ | — Limited role as a policy lever |
| | • Tax-free export zones | ◑ | — Some export zones available |
| | • Development areas | ◕ | — A number of development areas have been identified by the government, and are supported by incentives |
| | • Social policy | ◕ | — U.K. "safety net" for employees relatively weak by European standards (e.g., nonparticipation in EC social charter) |
| **Contextual Factors** | • Labour relations | ◕ | — Traditionally poor labour/management relations much improved; now strong relative to many European neighbors |
| | • Education of work force | ◑ | — Quality of state-run education poor relative to neighbors (e.g., Germany, Netherlands) |
| | • Research base | ◕ | — Traditionally excellent higher education and research in many areas, gradually being weakened by poor funding |
| | • Management skill | ◑ | — Moderately strong, but improving |
| | • Language | ● | — English remains the global language of business |
| | • Supplier infrastructure | ◑ | — Moderately strong relative to some European countries (e.g., Germany) |
| | • Supportive legal system | ● | — Stable legal system with no barrier to investment (e.g., risk of nationalization) |

recent years), and the property boom in the 1980s has caused long term damage to the housing market (which in turn drives important sectors of the economy). The departure of the U.K. from the Exchange Rate Mechanism also weakened the U.K.'s economic credibility with its European partners, since it represented a "U-turn" in a policy that the government had stated strenuously that it planned to pursue.

- **Regulatory framework.** In general, the U.K.'s regulatory framework is quite favourable towards investment; the Thatcher/Major government in particular has adopted a strongly encouraging stance. The U.K. also has a long legacy of encouraging investment, and, as noted in Chapter 1, has often been the innovator in new forms of investment support.

- **Contextual factors.** In the area of contextual factors, the U.K. presents a range of attractive and unattractive aspects. Overall, however, the U.K. is relatively strong in this area. On the positive side, labour relations in recent years are substantially better than the U.K.'s traditionally poor reputation would suggest; as Banham notes, the number of days lost in industrial disputes in 1992 was the lowest since records began over a century ago. The Economist Magazine survey of U.K. investment (*"Why here?"*) notes that a combination of contextual factors make the U.K. very attractive: long working hours (relative to the rest of the EC), weak trade unions and Britain's rejection of the EC social charter. The Economist survey suggests that ironically, poor management quality coupled with underinvestment makes the U.K. attractive to investors, since these factors have led to low national productivity and therefore low wages. Strange (1995) follows a similar line of reasoning, when he asserts that "the low labour productivity apparent in much of the U.K. industry must also encourage the Japanese company which intends to establish a competitive greenfield venture with the most modern plant and equipment." This interpretation, however is unusual; generally the perception of poor local management quality works against a location, since the costs of importing skilled management or training local personnel can be very high. The U.K. is also relatively unattractive in some contextual areas. For example, both the OECD and the World Economic Forum (reported by Flynn et al, 1994) rank the U.K. near the bottom of the twenty two developed countries surveyed in terms of overall level of education and skills. The IEE survey of surveys (1992) concludes that "the U.K. workforce, apart from the top level, is seriously underqualified." Banham (1994) also acknowledges the popular perception that British management is "relatively incompetent." This view holds that at least traditionally, there has been a shortage of managers in the U.K. with the requisite skills (e.g. implementing corporate strategies through effective project management and corporate capability building, willingness to take risks, level of comfort with pay/performance linkages). This point of view is echoed by the IEE survey which states that "management is improving but further gains are required to raise standards towards those of the best." The 1992 Coopers & Lybrand survey identified three managerial factors that have contributed to the decline of British manufacturing, in their view: short termism by management, attempts to apply quick fixes and insular attitude of management.

In summary, the U.K. represents an attractive market for manufacturing investment, especially when it provides access to the European market (Banham, 1994, Flynn et al, 1994, Cassell in the Financial Times Survey, 1993). Banham notes that the attractiveness of the U.K. has been well established. Forty percent of U.S. and Japanese investment in the EC over the last 40 years has been made in the U.K., and much of this investment has been made recently; the total stock of overseas direct investment in the U.K. increased from £18 billion in 1978 to £86 billion in 1989. The U.K. has also been a substantial beneficiary of investment from Germany.

However, there is also some reason for concern. The OECD places the U.K. 13th out of 22 in a league table of overall competitiveness, behind Japan, Germany and the United States. This poor ranking is driven by some of the factors identified above (e.g. management quality, poor labour skills). There is also some evidence that recently the U.K. has been facing increasing competition in attracting investment. Collis and Noon (1994) identify four factors: inadequate infrastructure provision, the skills gap, adverse perceptions of the attitude of the workforce and weakened financial incentives (e.g. since the abolition of the Regional Development Grant). To these should also be added external factors, such as the opening of Eastern

Europe, which has created yet more competition for investment funds.

### Capability based aspects

In this section, the impact of investment in the U.K. on corporate capability building will be discussed briefly. An earlier article I co-authored with Andrew Bartmess identified a five step process to make plant location decisions incorporating the impact of the decision on corporate capabilities (Bartmess and Cerny, 1993). One of the main conclusions of the article was that co-locating key functions was critical to preserving a company's capabilities. While this analysis must be performed at a company by company level, providing a summary of the capabilities available in the U.K. in different functional areas will provide some insight into the likely attractiveness of the U.K. from a capability building perspective.

A full analysis of the U.K.'s skills in major functional areas is beyond the scope of this work. However, it is helpful to identify a few of the U.K.'s areas of strengths and weaknesses. On the positive side, the U.K. has a strong R&D base, driven by underlying excellence in its academic scientific community. Banham (1994) notes that R&D expenditure by U.K. firms has risen 6 % in real terms between 1981 and 1991, although the IEE survey (1992) concluded that the U.K. is losing grounds on patent applications. In the area of marketing and advertising, the U.K.'s reputation for advertising is stronger than its reputation for marketing. Indeed, the U.K. is generally recognised as a world leader in advertising. Traditionally, however, there has been limited need for close ties between marketing/advertising and manufacturing, so this factor alone is not likely to influence plant location decisions significantly.

On the negative side, the U.K.'s skills in engineering related to design and production are considerably weaker. One of the arguments used for preserving manufacturing in an economy relates to the close linkage between design and manufacturing skills. In other words, losing manufacturing capabilities tends to lead to a reduction in engineering skills. Given the loss in manufacturing capability in the U.K., it is not surprising that the U.K.'s engineering design and production design skills are unremarkable relative to its European neighbours.

In summary, the U.K. is only a moderately strong investment location when viewed from a generic capability perspective. Naturally, this analysis is true only in the abstract: a specific company may have great strength in one of the functional areas identified as weak from a national perspective. Nonetheless, the investing company will need to import its own skills in these areas - it will not be able to leverage existing national strengths to build its own capabilities.

Given my methodology of assessing a country's attractiveness on the basis of cost and capability approaches, it is worthwhile to compare it to a different line of thinking taken by Porter (1990). He argues that a nation's competitive advantage depends upon its companies' ability to innovate and upgrade their capabilities. He proposes a framework to assess a nation's competitiveness in a given industry, which he titles the "diamond of competitive advantage". While there are some connections between his framework and mine, his emphasis is on industry groupings in a given country that gain competitive advantage on a global scale (e.g. Silicon Valley for semiconductors, the Italian tile industry). Nonetheless, to demonstrate the comprehensiveness of my proposed approach, it is helpful to articulate the linkages and show how the factors included in his approach can be included in my model when relevant (i.e. Figure 3.2).

Porter identifies four factors to assess a region's attractiveness: factor conditions, demand conditions, related and supporting industries and firm strategy, structure and rivalry. Porter's "factor conditions" (e.g. existence of skilled labour, quality of infrastructure) are largely picked up in my "economic environment" section. Porter gives great emphasis in his model to the second element, local demand conditions as a determinant of competitive advantage. While this can be true in some markets (see for example the discussion of Applied Materials in Bartmess and Cerny, 1993), it is not always an important factor in investment decision making. For example, the attractiveness of a car plant investment in the U.K. intended to serve the European market is little influenced by the character of the English car market. To the extent that local demand conditions are relevant for a given market, they can be incorporated in my framework under contextual factors. Porter's third element, related and supporting industries, is discussed above in the capability assessment approach (e.g. the quality of local R&D, advertising, etc.). His final element, firm strategy, structure and rivalry, can be very important in some industries, in that these elements are tightly linked with the element of local demand. However, as noted above, these need not necessarily be key aspects of an investment decision. If they happen to be, they can be incorporated in the contextual factors element of this framework.

### 3.2.3 Regional differences

Having described the U.K.'s attractiveness for investment on an aggregate basis, it is helpful to assess the relative strengths of England, Scotland and Wales. As noted in Chapter 2, the particular regional issues related to Northern Ireland will not be discussed in detail. This is a very brief overview of the relative differences, and is only intended to show that even at a high level, there are significant differences in overall policy approach across regions.

#### England

With its dominant financial role in the economy and especially its great political strength, the Southeast of England has not traditionally required special incentives to attract industry. Indeed, as was seen in Chapter 2, disincentives were put in place for many years to avoid over-concentration of investment in the Southeast. This has changed in the recent recession, when, for the first time, the Southeast was hit especially hard by an economic downturn. As was also noted in Chapter 2, a number of regions in England have remained financially depressed for many years (e.g. the

Midlands), despite many years of regional intervention.

### Scotland

Scotland has been quite successful in attracting local investment, based in part through active intervention to enhance its capabilities.[9] For example, the region has put in place a number of training programs to enhance local skills. It also has a good network of suppliers in key industries (e.g. computers and high technology), and has successfully adopted a number of new technologies and management practices (e.g. total quality management and statistical process control). Scotland has attempted to implement a modest industrial policy via the Scottish Development Authority (now Scottish Enterprise), built around "sunrise industries". However, this is a relatively recent trend. Hälkier has found that before 1985, more than 75 % of the investments made by the SDA were in "traditional" Scottish industries like engineering, textiles and food. Only in the late 1990s did the percentage of investment in "modern" industries (i.e. electronics, biotechnology and services) account for more than 50 %. Scottish Enterprise has attempted to raise awareness of its capabilities and potential by creating a fairly extensive network of overseas investment offices in the U.S., Asia, and Europe.

[9]This section draws upon material from Scottish Enterprise and Halkier (1992)

**Wales**

As David (1992) has noted, Wales has a number of characteristics that make it an attractive location for manufacturing investment. These include low overheads, low cost labour, recent investment in infrastructure (e.g. the rebuilt A55 along the north Wales coast, second Severn crossing), emphasis on selective attraction of investment related to core competencies (e.g. automotive components, electronics, aerospace), new housing developments (e.g. in Cardiff, Bridgend) and environmental rebuilding (e.g. the Cynon Valley). Collis and Noon (1994) suggest that Wales's attractiveness as a location for investment has been its low labour costs relative to other U.K. regions, generous regional assistance, new infrastructure investment and the general growth of the Welsh economy in relation to the U.K.

## 3.3 Degree of policy influence over the attractiveness assessment

Government policy cannot affect all aspects of a country's inherent attractiveness equally. This section provides a brief discussion of government influence over each of the four main elements of a country's attractiveness (i.e. Figure 3.2). In this way, it provides a linkage between the government policy levers identified in Chapter 2 and the perspective of a potential investing company.

- **Political environment.** The government has a moderate to low level of influence over the political environment (as defined in this framework). The broad features of English parliamentary democracy are unlikely to change significantly, particularly to meet the needs of investment policy, although clearly the government's overall attitude towards inward investment will depend upon the incumbent party.

- **Economic environment.** The government has significantly more ability to influence the economic environment, although the overall level is still only moderately high. While the government can influence the freedom of the market and currency convertibility, it cannot easily control the overall stability of the economy (as evidenced by the efforts of various Chancellors over the years to transform the economy from its inflationary, recession prone behaviour). The government's current fiscal woes create another significant constraint in improving the quality of the infrastructure, which arguably could improve the attractiveness of the U.K. for investors.[10]

- **Regulatory framework.** The government has a high degree of ability to influence the regulatory framework, in that the government directly controls nearly every aspect of it. Despite this control, the framework appears to change only very slowly. As noted in Section 2.2, regional policy and investment policy have shown a remarkable degree of persistence over five eras of regional policy spanning 60 years; by implication, governments have felt unwilling or unable to

[10]This is infrastructure broadly defined as in Section 2.4.1 above. It includes traditional elements such as roads, rail and telecommunications, but also includes "lifestyle" oriented elements such as quality of parks, hospitals, civic buildings, etc.

influence the regulatory framework significantly. The increasing power of the EC has also created some constraints (e.g. caps on investment subsidies, encouragement of the U.K. to adopt the Social Charter).

- **Contextual factors.** The government has a moderate degree of influence over contextual factors. While in theory the government can influence the quality of education, the skill of the research base and some aspects of management talent (e.g. through education policy), in practice it is extremely difficult to influence these factors effectively on a national scale. Some contextual factors are dependent only on the U.K.'s history and geographical location - i.e. English language being spoken and easy access being available to markets on the continent. Some further factors are inherently external, in that what is of interest to investors is the U.K.'s **relative** attractiveness when compared with its European neighbours. Thus while the U.K. government may have some influence over the quality of labour relations in the U.K., it can do little to influence the state of labour-management relations in other European countries.

Section 3.2.1 noted that awareness of a country's attractiveness also has a significant impact on corporate investment, and the resources required to fund promotional campaigns are under direct government control. In times of increasing fiscal constraint, however, the government may feel hampered in its ability to fund significant promotional campaigns for inward investment.

## 3.4 Summary and conclusions

This chapter has explored two key aspects of the overseas plant location investment decision: how companies make investment decisions and how they assess the inherent attractiveness of a particular location. It has discussed decision making based on both pure cost and capability based models, and has differentiated between rational and "behavioural" decision making. For my purposes, it will be assumed that all capability based elements can be assigned a cost, and that companies then make a rational decision on whether or not to invest based on the economic merits of the particular investment. The second half of this chapter has developed and discussed a framework for assessing a country's attractiveness for inward investment, and has applied it to the U.K.. The framework has confirmed that the U.K. has a moderate to high degree of attractiveness across the four key elements of the framework; this attractiveness has been reflected in the high level of overseas investment in the U.K.. The chapter concludes with a brief discussion of some of the regional differences between England, Scotland and Wales, and an analysis of the government's ability to influence factors affecting its attractiveness to overseas investors.

Drawing on the assumptions mentioned above, Chapter 4 that follows summarises the traditional financial approach companies use to evaluate investments, and then shows how this approach may be extended to incorporate recent research in investment decision making under uncertainty.

# Chapter 4

# Firm Investment Decision Making

The previous chapter described some important aspects of firm investment decision making, and identified two key assumptions that will hold for the remainder of this thesis. First, it stated the assumption that firm decision making will be considered to be "rational": investments are made solely on the basis of the true underlying economics. Second, it noted the assumption that all capability oriented factors may be incorporated into a financial model to describe those economics. This chapter summarises how firms currently use Net Present Value (NPV) analysis to assess investments, and then describes an original five step process which links together traditional NPV analysis with the findings from the McDonald and Siegel (1986) work.

## 4.1 Net Present Value Analysis

This section summarises the five steps in Net Present Value analysis (see Brealey and Myers, 1991 for a good overview of the subject). NPV analysis essentially assumes that an investment is a bond, i.e. it pays a periodic return to its investors. As will be discussed later, this assumption neglects an important aspect of an investment: its option value. While there is considerable practical subtlety in performing an NPV analysis, the underlying methodology is easy to articulate:

1. **Estimate the cash flows.** In many NPV analyses, it is assumed that the investment continues to pay a return in perpetuity; we will follow this approach here since the McDonald Siegel methodology makes a similar assumption. For practical reasons, however, detailed estimates are usually made of the likely revenues and expenses of a given investment for a specific period of years (typically between 5 and 20 years), and then broad assumptions are made regarding the behaviour of the investment following this period. The detailed revenues and expenses in the initial period are adjusted for non-cash items (e.g. depreciation and amortisation), and any tax benefits and working capital requirements can be included. We can denote the resulting cash flows as $CF_i$, where $i$ is the year which varies between 0 and $n$. For the cash flows from year $n+1$ to infinity, it is then assumed that $CF_{n+i} = CF_n \times (1+g)^i$ for all $i \geq 0$, where $g$ is an annual growth rate. In other words, cash flows beyond the final year grow at a constant rate (which may be 0).

**2. Establish a discount rate.** Next, a discount rate $r$ is established. This rate reflects the investing company's cost of capital, i.e. cost of funds used to make investments. It is typically estimated by computing the weighted average of a company's cost of debt and cost of equity.

**3. Compute terminal value.** The next step is to compute the "terminal value", i.e. the value of the cash flows from the year $n+1$ to infinity. The terminal value is usually computed as follows:

$$\text{Terminal value (TV)} = \frac{CF_n}{r-g}, \tag{4.1}$$

where $g$ is the growth rate.

**4. Discount the cash flows back to the present.** Using the discount rate, the future cash flows (including the terminal value) are discounted back to their value in today's money. Specifically, we create the sum

$$\text{Value}_0 = \frac{\text{TV}}{(1+r)^{n-1}} + \sum_{i=1}^{i=n-1} \frac{CF_i}{(1+r)^i}, \tag{4.2}$$

where $\text{Value}_0$ refers to the total value of the cash flow streams, discounted back to the present.

**5. Subtract initial investment to compute NPV.** Once we have computed the value of the future cash flow streams at time $t = 0$, we can then compare it to the required investment cost $I$. The decision rule is simple: "Invest if $\text{Value}_0 - I$ greater than 0."

The essential characteristic of this approach is that it leads to a decision rule about investing **today**, i.e. invest if the value of the discounted cash flows is greater than the cost of the initial investment. The method yields no information about what point **in time** to invest to achieve optimal returns. In addition, the cash flows are deterministic, i.e. they must be defined precisely for each year in the analysis. While there are some technical ways around this problem (e.g. Monte Carlo based simulation), these approaches do not address the problem that NPV analysis provides no information on the optimal time to invest.

## 4.2 Firm decision making including stochastic elements

Traditional NPV analysis cannot easily accommodate two types of elements: economic variables based upon geometric Brownian motion with drift and events that can be modeled by Poisson processes. Both of these are important in modeling the potential benefits of a given investment in an uncertain world.

### 4.2.1 Geometric Brownian motion with drift

Geometric Brownian motion with drift can be used to model variables that cannot be predicted with certainty, e.g. exchange rates, parts costs and labour costs. While it is possible to incorporate random elements in an NPV analysis (e.g. by simulating multiple trials using a computer programme such as At Risk), the end result is still a decision rule on whether or not to invest today, not a decision rule on when in time it is most advantageous to invest.

For the purposes of this research, uncertain economic variables will be modeled using geometric Brownian motion with drift. In other words, for a variable $x$, $dx$ would be given by:

$$dx = \alpha x dt + \sigma x dz,$$

where $dz$ is the increment of a Wiener process. In this equation, $\alpha$ represents the trend in the value of the variable, i.e. the expected linear increase over time. The other main parameter, $\sigma$, represents the expected volatility of the variable. The greater the value for $\sigma$, the greater the uncertainty of the variable over time. The parameters $\alpha$ and $\sigma$ can be estimated by reviewing historical data. Appendix A.1 describes these types of random variable in greater detail.

### 4.2.2 Poisson processes

Poisson processes can be used to model a second type of random variables, i.e. variables that make infrequent but discrete jumps. They are particularly relevant to this research in that they can be used to model a shift in policy, e.g. a change in tax rates or introduction of a minimum wage. These types of jump processes can be incorporated in a traditional NPV analysis by considering a "decision tree" with multiple possibilities. As before, however, the NPV analysis only reveals whether or not the investment has a positive return if made today, not when in time it is optimal to invest.

The specific mathematical treatment is as follows. If $q$ is a Poisson process, then:

$$dq = \begin{cases} 0 & \text{with probability} \quad 1-\lambda dt, \\ uq & \text{with probability} \quad \lambda dt \end{cases} \tag{4.3}$$

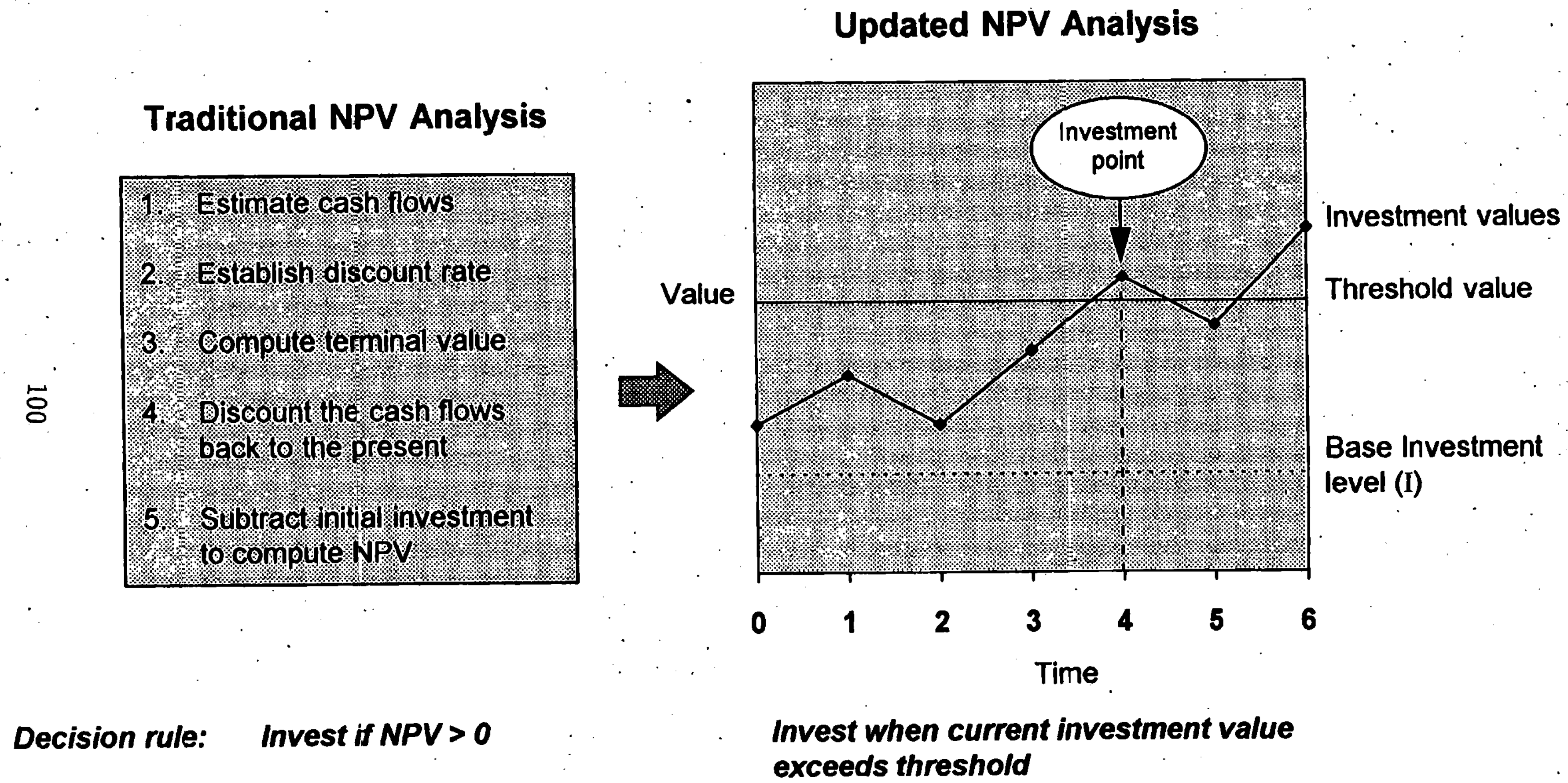
In other words, there is a $\lambda$ % probability that the value in $q$ will drop to $u$% of $q$, where $0 \leq u \leq 1$. Poisson processes are discussed in greater detail in Appendix A.4.

## 4.3 McDonald Siegel model

McDonald and Siegel (1986) developed an approach that describes a decision rule for investments that have values that vary according to geometric Brownian motion processes with drift.[1] Their analysis provides a significant improvement over traditional NPV analysis, in that it allows the investor to review the market situation regularly and choose the optimal time to invest. The difference between traditional NPV analysis and their approach is summarized in Figure 4.1. The left hand side of the chart summarizes the key steps in computing a NPV analysis and shows the

[1]The actual analysis also allowed the investment cost $I$ to vary stochastically as well. For the purposes of this research, however, it is assumed that $I$ does not vary in real terms (i.e. has parameters $\alpha = 0$ and $\sigma = 0$). This is a more realistic assumption in plant locations, where the cost of investment is relatively constant in real terms.

Figure 4.1:
**CONTRAST BETWEEN NPV ANALYSIS AND MCDONALD SIEGEL**



(static) decision rule. The right hand side of the chart shows the McDonald Siegel approach. First, a threshold value is computed that is larger than the base investment, $I$. Next, the actual value of the investment is monitored over time. When the current value exceeds the threshold value, the company invests, thereby ensuring the optimal return. Each of these steps entails considerable nuance, and will be described in detail in Section 4.4.

McDonald and Siegel's breakthrough was to derive an equation that could be used to compute the critical ratio - $C^*$ - which reflects the ratio of the required investment value divided by the initial investment, $I$. In computing this ratio, they assumed that the value of the investment $V$ could be modeled by geometric Brownian motion with drift, i.e. could be described by stating the two parameters $\sigma$ and $\alpha$. In their analysis, a company should invest at the first point in time when $V = f(t)$ exceeds the critical ratio $C^* \times I$. They derived an expression for $C^*$ as follows:

$$C^* = \frac{\beta}{\beta - 1}, \tag{4.4}$$

where $\beta$ is given by

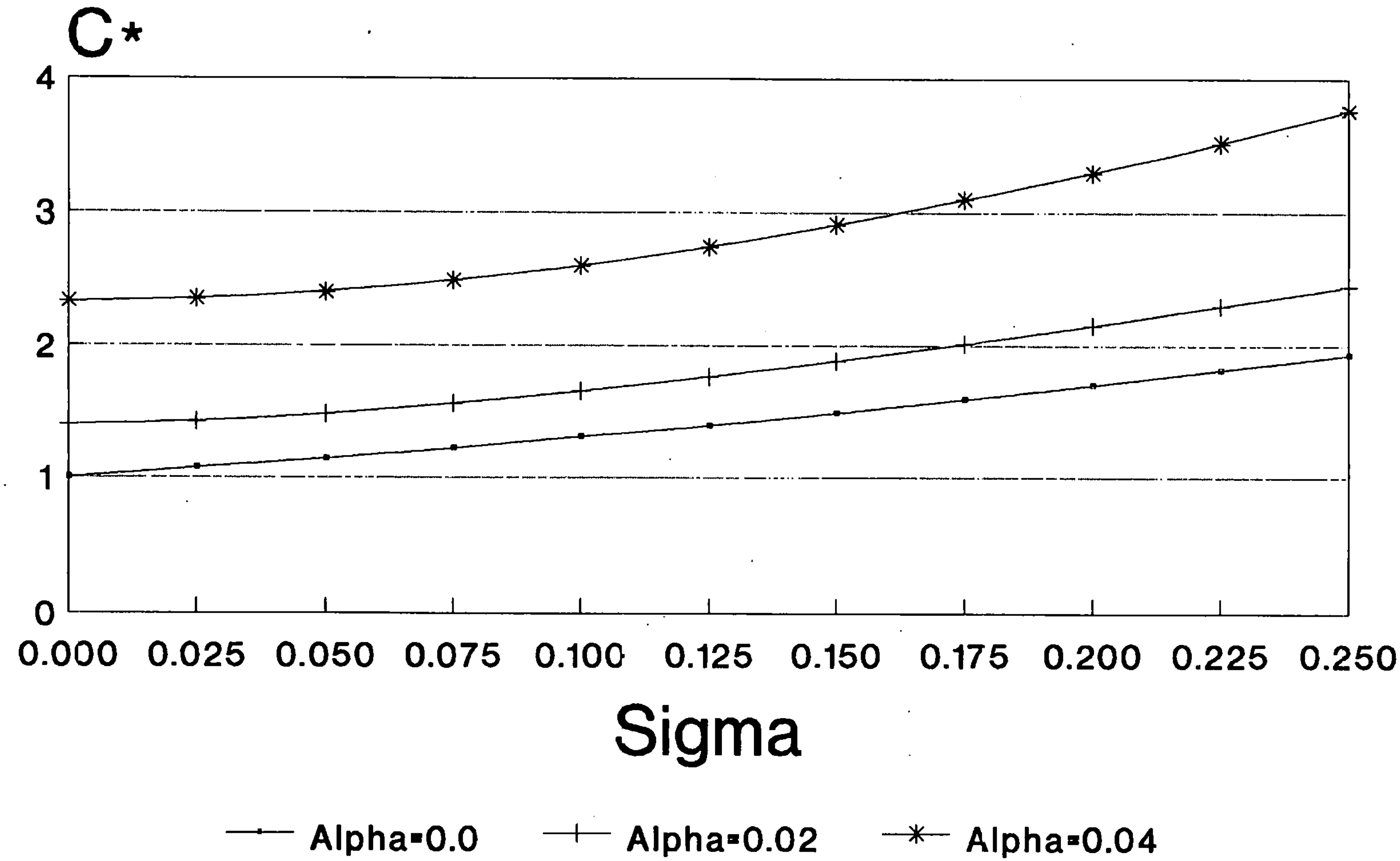
$$\beta = \frac{1}{2} - \frac{\alpha}{\sigma^2} + \sqrt{\left[\frac{\alpha}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2r}{\sigma^2}} > 0 \tag{4.5}$$

A detailed exposition of this analysis is given in Appendix A.

Having determined this equation, it is possible to identify the relationship between parameters $\alpha$ and $\sigma$ and $C^*$ (See Figure 4.2). For a fixed $\alpha$, the critical ratio increases sharply with $\sigma$. Thus for an $\alpha$ of .02 and a $\sigma$ of 20 %

Figure 4.2:

Variation of $C^*$ with parameters for $V$



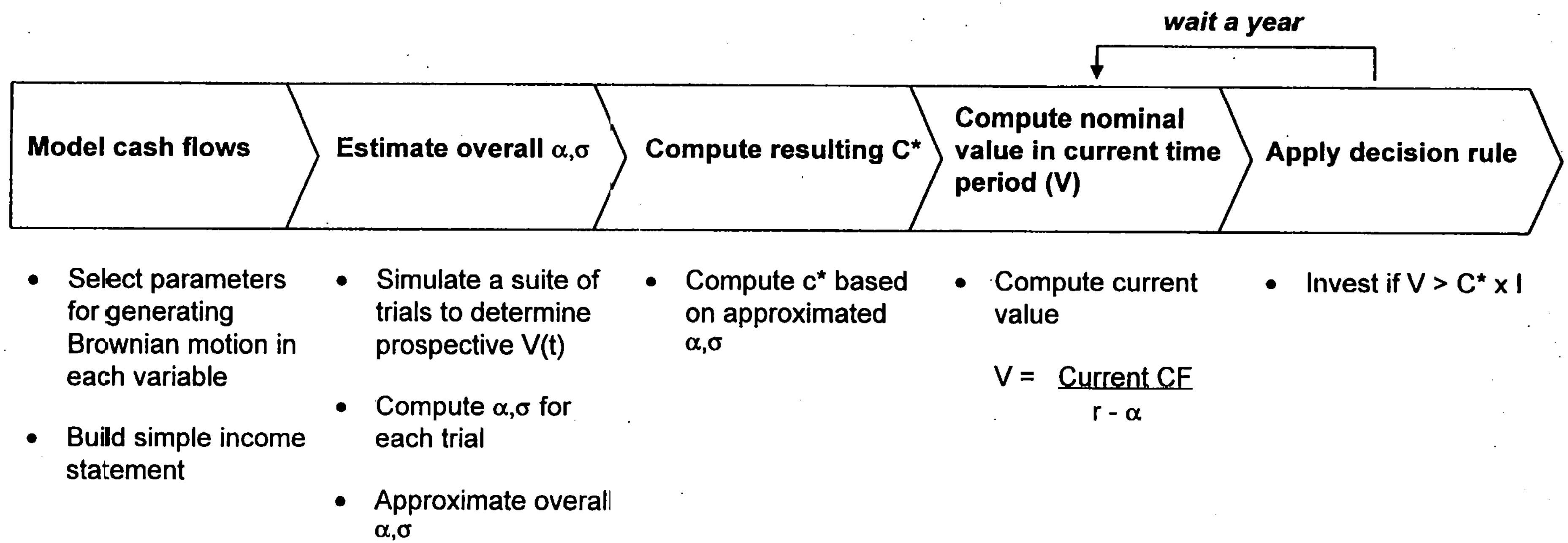
(a figure equivalent to the volatility of the stock market as a whole), the critical ratio is more than 2.0. From an economic perspective, the higher the volatility, the greater the possibility that the investment characteristics will change dramatically in the future. Therefore, in order to be sure that the best possible return is achieved, a company should only invest today if the current NPV is high (reflected by the increase in the critical ratio).

When $\alpha$ is varied, the same overall shape of the curve is preserved, but is shifted upwards: as $\alpha$ increases, the critical ratio increases. This behaviour reflects the fact that a positive $\alpha$ results in increasing value of the investment over time. The higher the value of $\alpha$, the greater the value in waiting to invest (i.e. to reap the benefit of increased future value), and therefore the higher the critical ratio.

## 4.4 Linking NPV analysis to McDonald Siegel

For the McDonald Siegel algorithm to be practical in real world decision making, some extensions to the approach are required. Their algorithm assumes that the value of the investment $V$ varies stochastically over time. Corporate decision makers, on the other hand, think in terms of the Net Present Value of a given decision. This section describes an original five step process which makes the required linkage (Figure 4.3). In essence, it provides an algorithm that permits the estimation of $\alpha$ and $\sigma$ for a given

Figure 4.3: Analytic process to link NPV analysis and McDonald Siegel



investment. The McDonald Siegel analysis may then be applied to determine the critical ratio.

The five required steps are described in detail in the following sub-sections.

### 4.4.1 Model cash flows

Suppose we are considering making an investment $I$ in a project that will generate revenues and expenses as represented below in Table 4.1. For the

Table 4.1: Sample cash flows from simple investment

| | 1995 | 1996 | 1997 | ... | |
|---|---|---|---|---|---|
| Sales | 100.0 | 100.0 | 100.0 | ... | |
| Labour expenses | 40.2 | 38.6 | 37.0 | ... | $Cost_i = Cost_{i-1}(1 + \alpha + \sigma dz)$ |
| Non-Labour | 20.0 | 20.0 | 20.0 | ... | |
| Profit | 39.8 | 41.4 | 43.0 | ... | |

purposes of the cash flow model, each variable is assumed to follow Geometric Brownian motion with drift, i.e. to be in the form $dV = \alpha V dt + \sigma V dz$. To model variables that are constant in real terms, such as sales in this example, the parameters $\alpha$ and $\sigma$ are both set to 0. The model excludes any Poisson processes; these will be discussed later in Section 4.4.6.

### 4.4.2 Estimate overall parameters $\alpha$ and $\sigma$

In the second step, we simulate a suite of trials to determine the value of the investment over time, $V(t)$. These values are calculated by using a ten year horizon and a terminal value. An average $\alpha$ is computed across the entire suite of trials; $\sigma$ can then be computed for each trial and an overall average taken. The parameters may then be used as the main parameters in the McDonald Siegel equation used to estimate $C^*$.

Deriving expressions for the estimate of the main parameters is straightforward. We first write the formula $dV = \alpha V dt + \sigma V dz$ in terms of finite differences as $\Delta \ln V = \alpha \Delta t + \sigma \Delta z$. Since expectation is a linear operator, we can write:

$$\begin{aligned} \mathcal{E}(\Delta \ln \mathrm{V}) &= \alpha \mathcal{E}(\Delta \mathrm{t}) + \sigma \mathcal{E}(\Delta \mathrm{z}) \\ &= \alpha \text{ since } \mathcal{E}(\Delta \mathrm{t}) = 1 \text{ and } \mathcal{E}(\Delta \mathrm{z}) = 0 \end{aligned}$$

Next, we note that $\mathrm{Var}(\Delta \ln V) = \mathrm{Cov}\ (\Delta \ln V, \Delta \ln V)$. Then we can write:

$$\begin{aligned} \mathrm{Cov}(\Delta \ln V, \Delta \ln V) &= \mathrm{Cov}(\alpha \Delta t + \sigma \Delta z, \alpha \Delta t + \sigma \Delta z) \\ &= \alpha^2\ \mathrm{Cov}(\Delta t, \Delta t) + 2\alpha\sigma\ \mathrm{Cov}(\Delta t, \Delta z) + \sigma^2\ \mathrm{Cov}(\Delta z, \Delta z) \end{aligned}$$

Next we note that:

$$\mathrm{Cov}(\Delta t, \Delta t) = 0 \text{ since } \Delta t \text{ deterministic} \tag{4.6}$$

$$\mathrm{Cov}(\Delta t, \Delta z) = 0 \text{ since } \Delta t \text{ and } \Delta z \text{ uncorrelated} \tag{4.7}$$

$$\text{Cov}(\Delta z, \Delta z) \;=\; \Delta t \text{ from the definition of Brownian motion} \quad (4.8)$$

Therefore, $\text{Var}(\Delta \ln V) = \sigma^2 \Delta t = \sigma^2$ for $\Delta t = 1$

Thus for a given trial of $n$ years, we can write:

$$\alpha = \frac{\ln v_n - \ln v_1}{\text{n}} \quad (4.9)$$

$$\sigma^2 = \frac{1}{n-1} \sum_{i=1}^{n-1} \left[ \ln \left( \frac{v_{i+1}}{v_i} \right) - \alpha \right]^2 \quad (4.10)$$

These two equations are used to estimate the average $\alpha$ and $\sigma$ for the overall investment across the suite of trials. They are also used to estimate the parameters for historical data used as inputs to the cash flow analysis (e.g. to compute the historical volatility and trend of labour rates).[2]

One issue is that since $\alpha$ and $\sigma$ are estimates, it is important to estimate the size of the error bars on these variables. In general,

$$\frac{1}{\text{standard deviation of } \alpha} \sim n$$

$$\frac{1}{\text{standard deviation of } \sigma} \sim \sqrt{n}$$

A sensitivity analysis of the impact on the number of trials on the overall estimate for $\sigma$ is shown in Section 5.7.

[2]See Section 5.4.

### 4.4.3 Compute resulting $C^*$

The third step is to compute the overall critical ratio, based upon $\alpha$ and $\sigma$. This is straightforward, relying upon the fact that:

$$C^* = \frac{\beta}{\beta - 1}, \tag{4.11}$$

where $\beta$ is given by equation 4.5.

### 4.4.4 Compute nominal value in current time period

The fourth step is to compute the value of the investment over time, in order to apply the investment rule. A set of random numbers is generated, in order to determine the "actual" path for the three main variables in the model (sales, labour costs and non-labour costs). For each year, the current value $V$ of the investment needs to be estimated. The equation used is:

$$V = \frac{CF_i}{r - \alpha}, \tag{4.12}$$

where $CF_i$ represents the cashflow in year $i$. This expression follows directly from traditional NPV analysis. Since the expected value of any geometric Brownian variable is independent of $\sigma$, that term does not appear in this equation. The above equation is therefore parallel with the equation for estimating the terminal value in traditional NPV analysis (i.e. equation 4.1).

### 4.4.5 Apply decision rule

Now, the formal decision rule may be applied. Each year (or any regular time period), the company checks to see if:

$$V \geq C^* \times I,$$

where $V$ is given by equation 4.12. If so, the company invests at that point. If not, it waits until the next time period and reapplies the rule.

### 4.4.6 Overlay of Poisson processes

It is possible to overlay multiple Poisson processes over the approach described above (Dixit and Pindyck, 1994, extended by the analysis in Appendix A). This overlay can then incorporate the impact, for example, of a 10% probability per year of a drop of 20% in the value of the investment. We can use the method shown in Appendix A.4, and the following equation to calculate the impact on $C^*$.

$$\frac{1}{2}\sigma^2\beta(\beta-1)+\alpha\beta-(r+\sum_i \lambda_i)+\sum_i \lambda_i(1-\phi_i)^\beta=0, \tag{4.13}$$

where $\lambda_i$ and $\phi_i$ are the two parameters used to define a total of $i$ distinct Poisson events. Simple numerical solutions may then be used to solve for $\beta$. Once $\beta$ is known, $C^*$ may be computed. Some detailed case examples using this technique will be developed in section 6.3.3.

### 4.4.7 Linkage between company hurdle rates and cost of capital

The McDonald Siegel analysis also helps to resolve an open question relating to traditional Net Present Value analysis: why company hurdle rates[3] used in NPV analysis are so much higher than their true cost of capital. As Dixit (1992) has noted, "observers of business practice find that such hurdle rates are three or four times the cost of capital." He finds that it is possible to incorporate a new discount or hurdle rate that takes account of the value of waiting. In fact, the adjusted cost of capital $\rho^*$ can be found as:

$$\rho^* = \frac{\beta}{\beta - 1}\rho,$$

where $\rho$ is the cost of capital as described in Section 4.1. As he notes, "even when the cost of capital is as low as 5 percent per year, the value of waiting can easily lead to adjusted hurdle rates of 10 to 15 percent." It can be shown that Dixit's approach and the five step method described above based on McDonald Siegel are the same; one adjusts the discount rate and one creates a new investment threshold. While this approach is unlikely to reflect the entire explanation for the disparity between NPV theory and common business practice, it does provide a thought provoking rationale for why company investments are apparently made too conservatively.

[3]The "hurdle rate" is the minimum financial return a company will accept in order to fund a given investment

## 4.5 Summary

This chapter has laid some important technical groundwork for the work that follows. It began with a brief discussion of traditional NPV analysis, and noted two important types of elements that cannot easily be incorporated into NPV analysis: variables that can be described by geometric Brownian motion and Poisson type events. Next, the chapter described the McDonald and Siegel (1986) algorithm and developed a five step process to link traditional NPV analysis with their approach. The chapter concluded by indicating how the Dixit and Pindyck (1994) algorithm may be used to incorporate Poisson events in the five step approach. This topic will be covered in more detail in Chapter 6.

Chapter 5 that follows describes an analytical model, based upon fieldwork with Kodak, that incorporates the five step process described here. Chapters 4 and 5 therefore provide the analytical tools required for identification and analysis of potential new policy instruments in Chapter 6.

# Chapter 5

# Kodak Investment Model

The previous chapter outlined the detailed mathematical theory required to link traditional NPV analysis with the McDonald Siegel approach. This chapter describes five major areas: the conceptual design of a computer model based upon this theory; the approach used to estimate sales revenues and the expense cost structure; the actual model design and structure; the methodology used to estimate key parameters; and a discussion of a sample printout of the model (including potential enhancements).

## 5.1 Conceptual design of computer model

In order to test the new policy instruments discussed in Chapter 6, a detailed case example of an investment decision was required. This section describes the approach used to develop a computer model based upon this case example, and some key simplifying assumptions.

### 5.1.1 Development of the Kodak model

To provide "real life" numbers for the investment decision model, I selected the example of a Kodak investment decision that was in the public domain (i.e. a Harvard Business School case written by myself and Andrew Bartmess, 1992). This publication was based upon extensive fieldwork that we conducted in 1991 with the Kodak Business Imaging Systems Division operation in Rochester, NY. To preserve the confidentiality of Kodak proprietary data, I have disguised any data relevant to the investment model that were not already in the public domain (e.g. actual level of R&D spend). In doing this, I have been careful to ensure that none of the adjusted information would have any material impact on the potential investment decision analysis.

The original case example described the decision making process of senior management at Kodak's Business Imaging System Division (BIS), who were considering relocating manufacturing operations from relatively high-cost Rochester to a low cost Asian location. BIS designed, manufactured, marketed and sold microfilm readers and printers, ranging from small desktop units to large units capable of serving a large commercial bank. Although the division had traditionally been quite successful, based in part on the strength of the Kodak brand name, it had been coming under increasing pressure from low-cost Asian manufacturers.

For the purposes of this thesis, the Kodak case has been adapted to reflect a greenfield investment. This change has been made to reflect the fact that the U.K. is more likely to attract new investment than purely cost-based relocations, given that its labour costs are relatively high (e.g. when compared with Thailand). From a financial modeling perspective, this change has relatively little impact, however; the same computer model can be used to evaluate greenfield investments or plant relocations.

The specific product selected for the analysis was the one referred to as "Capture I" in the Kodak case. Capture I was a low cost, high volume product that would be a logical candidate for either a cost based relocation or a greenfield investment seeking an attractive location.

### 5.1.2 Simplifying assumptions in model

The original investment model was highly complex (See "Model Note" by Cerny and Bartmess, 1992), since it was intended to capture nearly all aspects of the investment decision in detail (e.g. expatriate support, fine gradations of duty costs, etc.) Incorporating this level of detail in the policy instrument analysis ran the risk of obscuring the underlying economics, however, and therefore the investment decision model was simplified in several ways:

- **Income statement.** At the core of every investment decision model is a cash flow analysis that describes the expected cash flow from the investment. For the purposes of this analysis, the cash flow statement was simplified to include just three variables: sales, labour costs and non-labour costs (e.g. optical and mechanical parts).

- **Types of variables considered.** In computing the likely cash flows over time, it was assumed that all three variables followed geometric Brownian motion with drift. This allowed variables to be held constant in real terms, if desired, by setting $\alpha$ and $\sigma$ to 0. The same model could also be used to incorporate variables following other types of random motion, if desired.

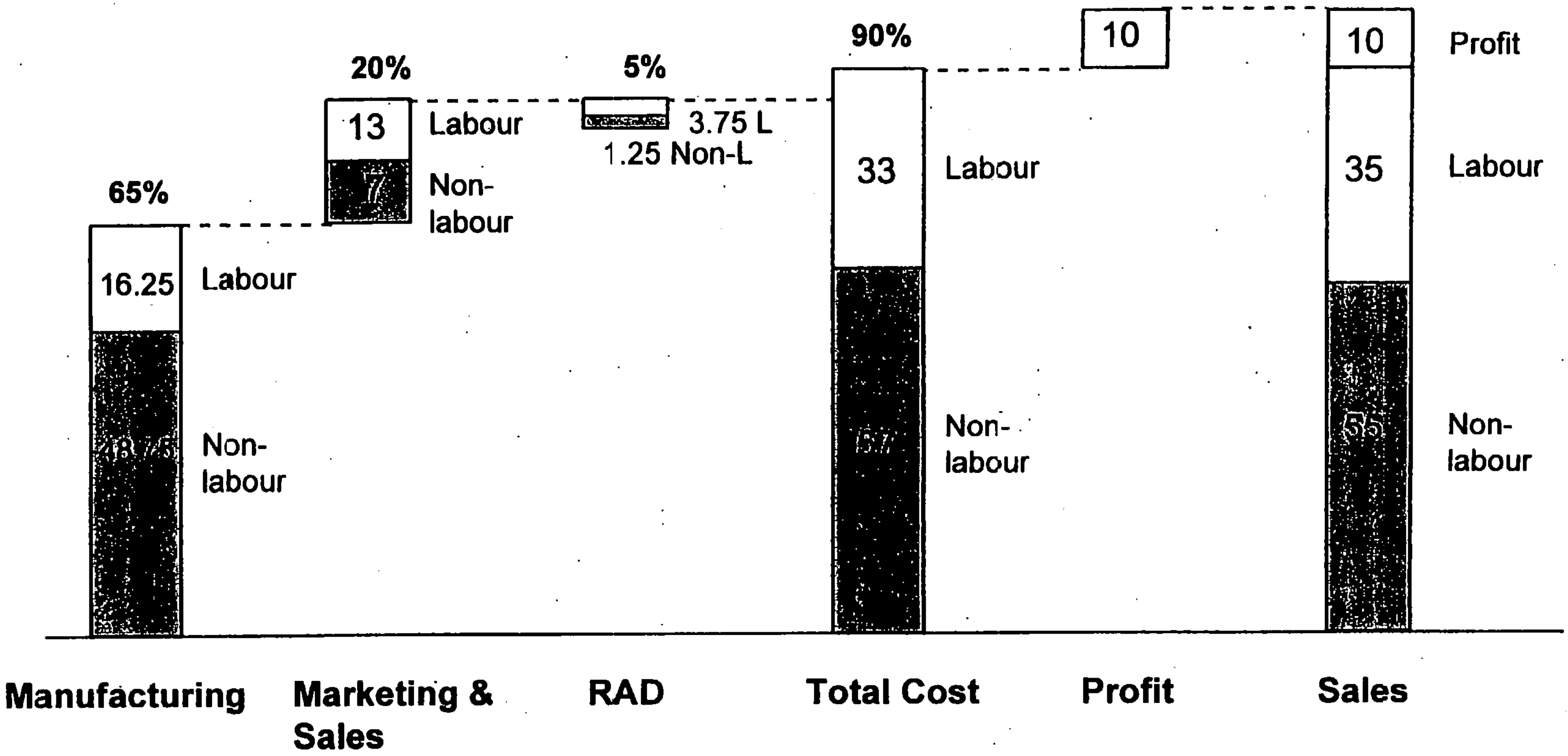
- **Approach to taxation.** The impact of a profits tax was included in the model, although no effort was made to model more sophisticated aspects of taxation such as tax carryforwards and carrybacks.

Despite these simplifications, the resulting model displays considerable analytical richness. It also provides enough detail that it could be applied to more complex situations (although at a cost in loss of clarity on the impact of uncertainty on the underlying economics).

## 5.2 Estimating sales revenues and underlying cost structure

One of the key analyses in the model design was the conversion of the overall economics of the investment decision into the three elements described above: sales, labour based costs and non-labour based costs. Figure 5.1 shows the result of this analysis. Out of a total selling price of 100 (on an index basis), labour driven costs accounted for 35% of the total and non-labour driven costs accounted for 55% of the total, yielding a

Figure 5.1:
**OPTOELECTRONICS DEVICE COST STRUCTURE**
**PERCENT OF SELLING PRICE**



profit of 10%.[1] These figures were then used in the cash flow model.

To develop these figures, an analysis was conducted of the key elements of the Kodak cost structure. These were total profit, R&D spend, marketing and sales spend, and manufacturing spend. For each of these elements, the proportion of total cost attributable to both labour driven costs and non-labour driven costs was estimated. To perform this analysis, data from Kodak and public data from competitors were used. Specific results were as follows:

- **Total profit.** The simple analysis of profitability of Kodak and competitors (e.g. Canon, Anacomp, AGFA) showed a return on sales (i.e. pre-tax profit divided by sales) of only 5%. However, the market was particularly competitive during the period of time reflected by the data (i.e. 1985 to 1990), and therefore a pre-tax ROS of 10% was selected to be modeled. This is more typical of successful manufacturing companies.

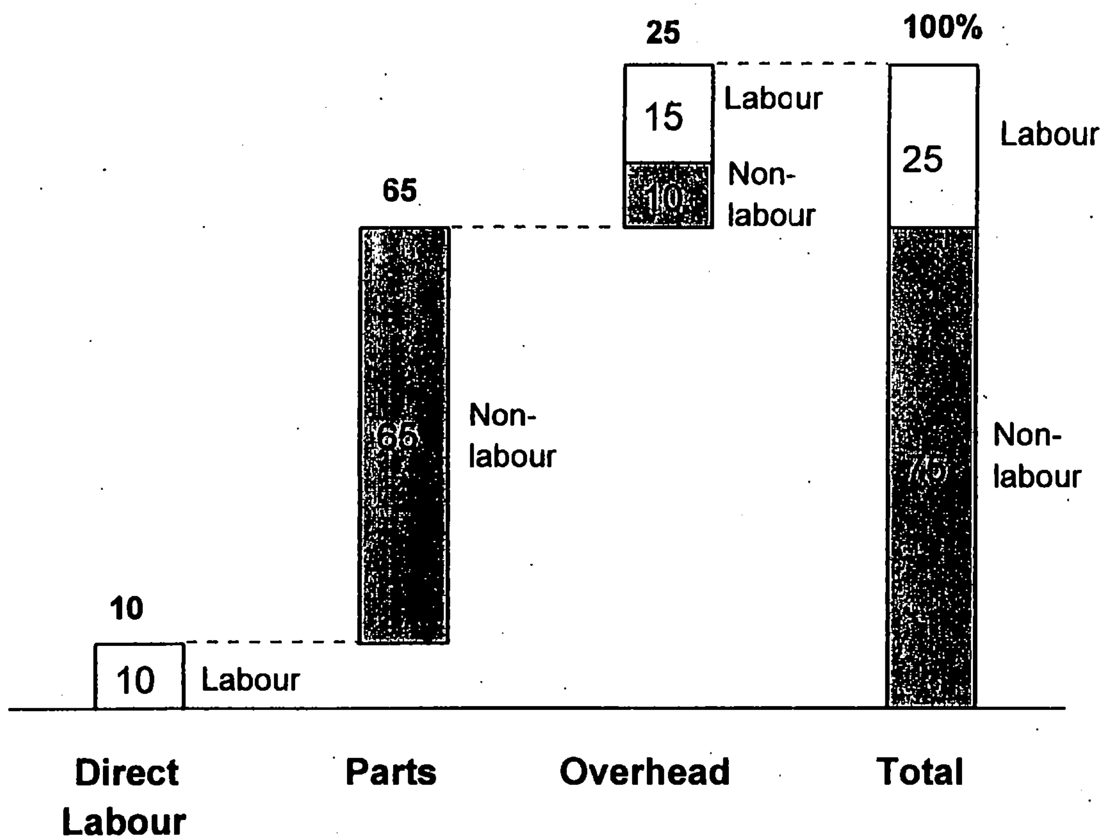
- **R&D.** Although analysis of Kodak and competitor data showed a fairly wide variation in R&D spend, a figure of 5% was selected as being typical. R&D was assumed to be heavily labour cost driven, and therefore a 75:25 split was assumed between labour driven and non-labour driven elements. This 75:25 split implied that R&D's contribution to the total cost structure was therefore 3.75% labour driven and 1.25% non-labour driven.

[1]These numbers were rounded to the nearest 5%

- **Marketing and Sales.** Marketing and Sales reflected approximately 20% of the total sales price. This expense was assumed to be split 65:35 between labour and non-labour, to reflect the people intensity of that part of the business. This implied that labour-cost driven Marketing and Sales expenditure represented 13% of the total cost structure and non-labour cost driven expenditure represented 7%.
- **Manufacturing spend.** By analyzing Kodak and competitor data, it was determined that the cost of manufacture was approximately 65% of the total selling price. The split between labour and non-labour driven costs is described in detail below.

Having analysed each major cost element at a top level, the next step was to identify the split between direct labour and non-direct labour for the manufacturing costs. This split was calculated using data from the original fieldwork and the Harvard Business School case (Figure 5.2). Labour costs, both hourly and salaried, were assumed to be comparably volatile, and were assumed to account for 10% of total cost. Parts were assumed to be driven by non-labour costs from the perspective of the investing company, and represented 65% of the total cost structure. Overhead contributed 25% to the total manufacturing cost, and was assumed to be split 60:40 between labour and non-labour to reflect the significant fixed costs associated with manufacturing the equipment (e.g. in tooling). These assumptions were supported by data in the case and interviews conducted when the case was being written.

Figure 5.2:
**OPTOELECTRONICS DEVICE MANUFACTURING COST STRUCTURE PERCENT OF MANUFACTURING COST**



## 5.3 Model design and structure

A detailed computer spreadsheet model of the Kodak investment decision was constructed, that incorporated the analytical techniques described in Chapter 4 (Figure 5.3). Specific elements of the model were as follows:

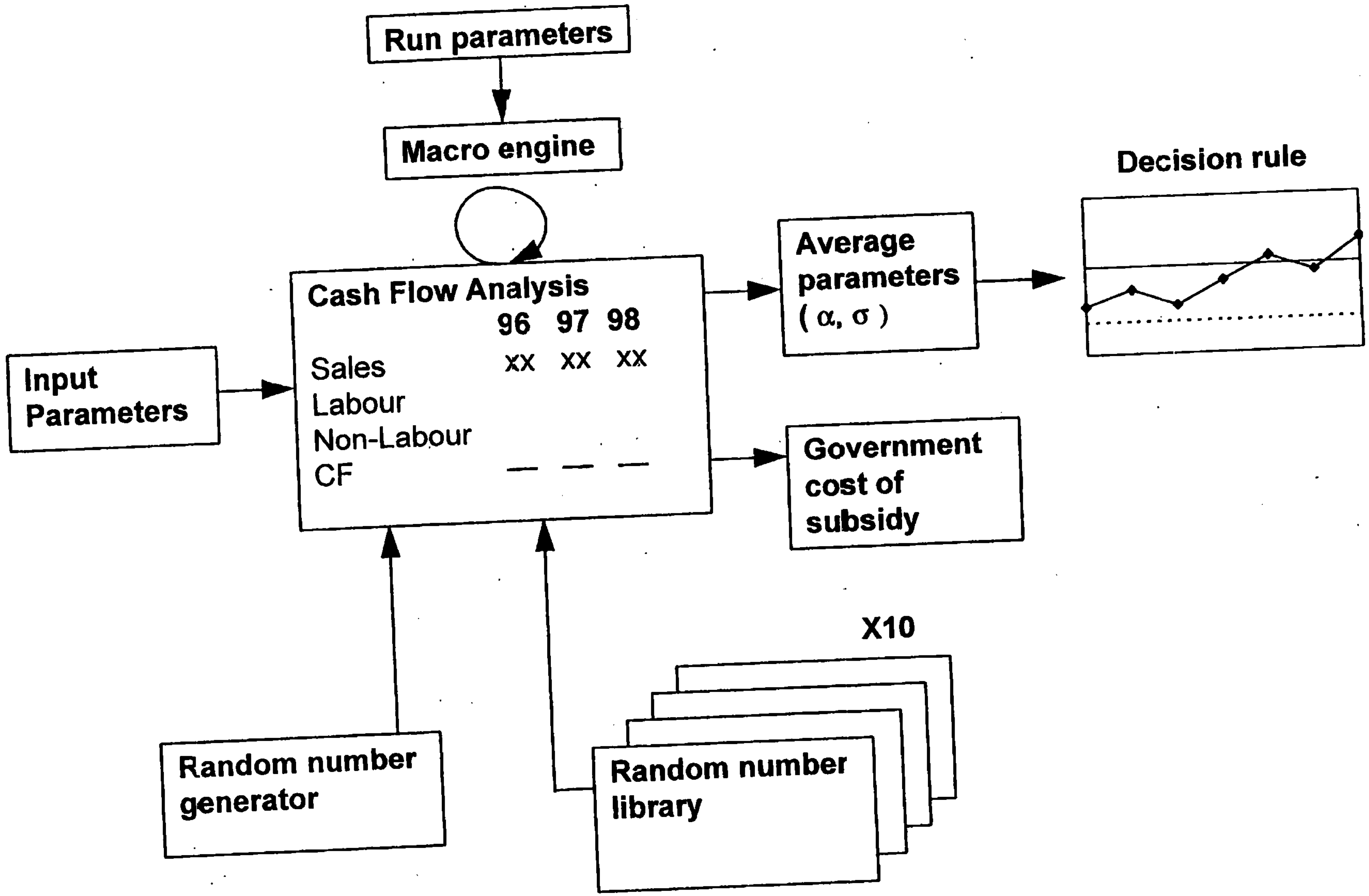
- **Cash flow analysis.** At the heart of the model was a traditional cash flow analysis, incorporating the three cost elements noted above (i.e. revenue, labour driven costs, non-labour driven costs). The model permitted up to five variables to be included, and each variable was modeled independently based upon the two parameters required to define geometric Brownian motion with drift. Twenty years of random variables were forecast, and ten years of Net Present Values were computed by summing the discounted value of ten years of a simulated series of cash flows, plus a discounted terminal value.

- **Input parameters**. Each forecast variable requires the usual two parameters to define it: $\alpha$ and $\sigma$. To estimate these, a two step process was used that is described in detail in Section 5.4.

- **Random number generator**. Based upon the mathematical techniques described in Appendix A.5, a macro driven random number generator was included that produced the required normalized distribution.

- **Random number library**. Because computations of the required random numbers were very time intensive (up to 8 hours for a full set

Figure 5.3:
**COMPUTER MODEL**



on a 33 MHz Compaq 486), a library of 10 sets of random numbers was created. This approach had two benefits. First, it reduced the required run time per simulation from approximately 8 hours to 5 minutes. Second, it allowed more precise comparisons between different policy instruments, since the calculations could be based upon the same random variables (if required).

- **Macro engine.** Since calculating the overall parameters required running multiple trials (up to 100 or more) to generate average values, a macro "engine" was added to the spreadsheet to manage the overall simulations. The macro engine also accessed random numbers from the library or generated new ones as required.

- **Run parameters.** The macro engine had three main parameters. The first controlled the number of trials in each simulation that were executed to produce the overall average parameter values. The second and third parameters controlled the number of random numbers produced by defining the row and column widths of the matrix to be filled.

- **Output parameter estimation.** Estimating the output parameters relied upon equations 4.9 and 4.10, but provided three options in how the average $\alpha$ was computed across simulations. One option held $\alpha$ fixed at 0. The next option subtracted the average $\alpha$ in each simulation run from the logarithm pairs used to calculate $\sigma$ in equation 4.10. The final option computed an overall $\alpha$ across the entire suite of trials, and used this $\alpha$ to calculate $\sigma$. The analysis in Chapter 6 relied upon the third approach, since it produced the most consistent results of the three. This is because the first was relevant only for special cases (e.g. when the drift value for all three input variables was 0). The second approach ran the risk that small errors in calculating $\alpha$s for each trial in the suite would lead to errors in estimating $\sigma$s for each trial.

- **Decision rule.** The general decision rule, as noted earlier, is to invest when the current year NPV estimate exceeds the required threshold value. This portion of the model incorporated two calculations. First, it computed the value of $C^*$ and therefore the value of the threshold. Second, it captured the evolution of value over time so that the investment point could be selected.

- **Cost of subsidy calculations.** The final section of the model computed the year by year and average cost to the government of the volatility minimisation instrument. The detailed calculation techniques employed will be described in detail in Section 6.3.1.

## 5.4 Economic parameter estimation

To estimate the two parameters for key economic variables (e.g. labour cost), a two step approach was used. First, $\alpha$ and $\sigma$ were computed for these variables based upon published real economic data from CSO Economic Trends. To do this, equations 4.9 and 4.10 were used, computed over two different time periods. Three of the variables were expressed in nominal terms (i.e. producer price index, "cable" exchange rate[2] and exchange rate index), and so required conversion to real terms by dividing by the appropriate inflation index. Four variables in all were selected for detailed examination (Table 5.1):

- **Average manufacturing earnings.** The CSO baseline manufacturing earnings data are seasonally adjusted, which tends to flatten the true volatility. To reverse this flattening, an index was created that compared unadjusted and seasonally adjusted series of the producer price index. This index was then applied to the raw manufacturing earnings data. While the trend figure was unchanged in the 15 year period, it changed slightly in the 10 year period. More importantly, the true volatility rose significantly to .047 and .045 for the two periods.

- **Producer price index.** The volatility and trend were estimated for the producer price index, i.e. the average cost of goods used in manufacturing. Here the trend and volatilities were quite similar over the two time periods (-.037 vs. -.052 and .057 vs. .053, respectively).

- **Cable exchange rate.** The average volatility of the "cable" exchange rate was computed, since approximately 50% of sales from the Kodak plant were to the U.S. market. Although the trend figure was quite different for the two periods (-.088 vs. -.019), the

[2] "Cable" is shorthand for the U.S. dollar to English pound exchange rate

Table 5.1:

## ECONOMIC PARAMETERS

### *Stochastic Parameters - Real**

| | 1980(Q1)-1994(Q2) | | 1985(Q1)-1994(Q2) | |
|---|---|---|---|---|
| | α | σ | α | σ |
| Average manufacturing earnings (seasonally adjusted) | 0.021 | 0.026 | 0.020 | 0.027 |
| Average manufacturing earnings (corrected for seasonal adjustments)** | 0.021 | 0.047 | 0.018 | 0.045 |
| Producer price index* | (0.037) | 0.057 | (0.052) | 0.053 |
| Cable exchange rate (£ = $)* | (0.088) | 0.118 | (0.019) | 0.121 |
| Exchange rate index* | (0.084) | 0.072 | (0.067) | 0.079 |

* Adjusted by RPI series
** Estimates based upon unadjusted and seasonally adjusted series of the producer price index

*Source: CSO Economic Trends*

underlying volatility was very similar (.118 vs. .121)

- **Exchange rate index.** The trend and volatility was also estimated for two different periods for a basket of European currencies. As in the cable exchange rate calculation, the volatilities were very similar across two time periods (.072 vs. .079), and the trend was much closer (-.084 vs. -.067).

Having determined the parameters for the key macroeconomic variables, the second step was to incorporate these parameters into the three variables used in the model described above. Table 5.2 shows the assumptions made for the three key cash flow elements. The parameters for labour-based costs

Table 5.2: Parameters used in Kodak model

| | $\sigma$ | $\alpha$ | Rationale |
|---|---|---|---|
| Sales | .08 | 0 | Average of cable, sterling indices |
| Labour costs | .047 | .021 | Based on historical data |
| Non-labour costs | .057 | $-.037$ | Based on historical data |

and non-labour based costs were based directly from the data found in Table 5.1. The fifteen year time period was selected to minimize errors from fitting data to a shorter period. Setting parameters for the sales variable required some additional analysis. A typical startup will show great volatility in sales as it enters the market. A plant relocation will show much less volatility, assuming that the products produced at the previous location were already well established in the market. For the purposes of this model, it was assumed that the sales trend would be zero in real terms, i.e. that there would be no overall growth ahead of inflation. A figure of .08 was selected for the volatility, which reflects the volatility of the index of European currencies. As will be seen below, even this relatively low level (e.g. versus .12 for the cable exchange rate) has a significant impact on a company's likelihood to invest.[3]

## 5.5 Model printout and discussion

This section begins with a detailed description of the computer model used to assess the policy instruments in Chapter 6. It then describes some sensitivity analysis used to estimate the number of trials required per suite, and concludes with a brief discussion of some potential refinements to the model.

### 5.5.1 Sample output and discussion

A printout of a sample run of the model is shown in Appendix C. The elements of the computer model are as follows:

- **Cashflow simulation.** Page C-1 of Appendix C contains a number of key elements of the overall simulation:

[3]It is important to note that actual currency risk may be hedged wholly or partially using financial instruments. The volatility figure selected is intended to be a proxy for volatility in sales.

- *Main parameters.* The "fit period select" variable controls how long a simulation period is used. In all trials, the value of the prospective investment is computed over a ten year period plus a terminal value. The variable "WACC" refers to the weighted average cost of capital in real terms; a figure of 7% was selected as being typical. The tax rate used is 33.25%. The model is constructed in real terms, and therefore the figure for inflation is set to zero.
- *Cashflow model.* The key element of the first page is the cashflow estimate. These cashflow estimates are used to estimate the value over time from the investing company's perspective. Each value is calculated based on a ten year series of simulated cash flows, plus a discounted terminal value (See equation 4.2).
- *Random number set.* This page transfers random numbers from the matrix on page C-8. The variable "random number offset" is used to select which random numbers are used from the matrix for each random number set. The "number of variables" figure controls how many stochastic variables are modeled, in this case three.
- *Trend and volatility parameters.* The table at the bottom of the page summarizes the $\sigma$ and $\alpha$ used for each random variable.

- **Government cost calculation.** The page used to compute the government subsidy for the volatility minimisation instrument is shown on page C-2 of the Appendix. The "base case" reflects the original simulated figures shown on page C-1. Here the subsidy being modeled is found by setting the volatility of labour and non-labour cost to zero. By computing the difference between labour and non-labour cost between the base case and the government subsidy case, it is possible to calculate the 10 year cost of the subsidy. By re-running the model and setting the volatility for the labour cost and non-labour cost to 0 (i.e. on page C-1), it is possible to compute the resulting new critical ratio. Section 6.2.2 discusses this analytical approach in more detail.

- **Model inputs**. Page C-3 includes three model inputs. "Simul" is the number of simulation runs in the suite. Variables P and Q determine the size of the random number matrix that is generated (Page C-8).

- **Valuation outputs**. Page C-4 stores the value streams for each successive run in the suite of trials. The alpha column shows the $\alpha$ of each particular stream of values. The average alpha figure averages all the $\alpha$s across the suite of trials. The two values at the top of the page, "Invest in year 0" and "Invest before year 10" are used to monitor the investment rate given the initial investment $I$.

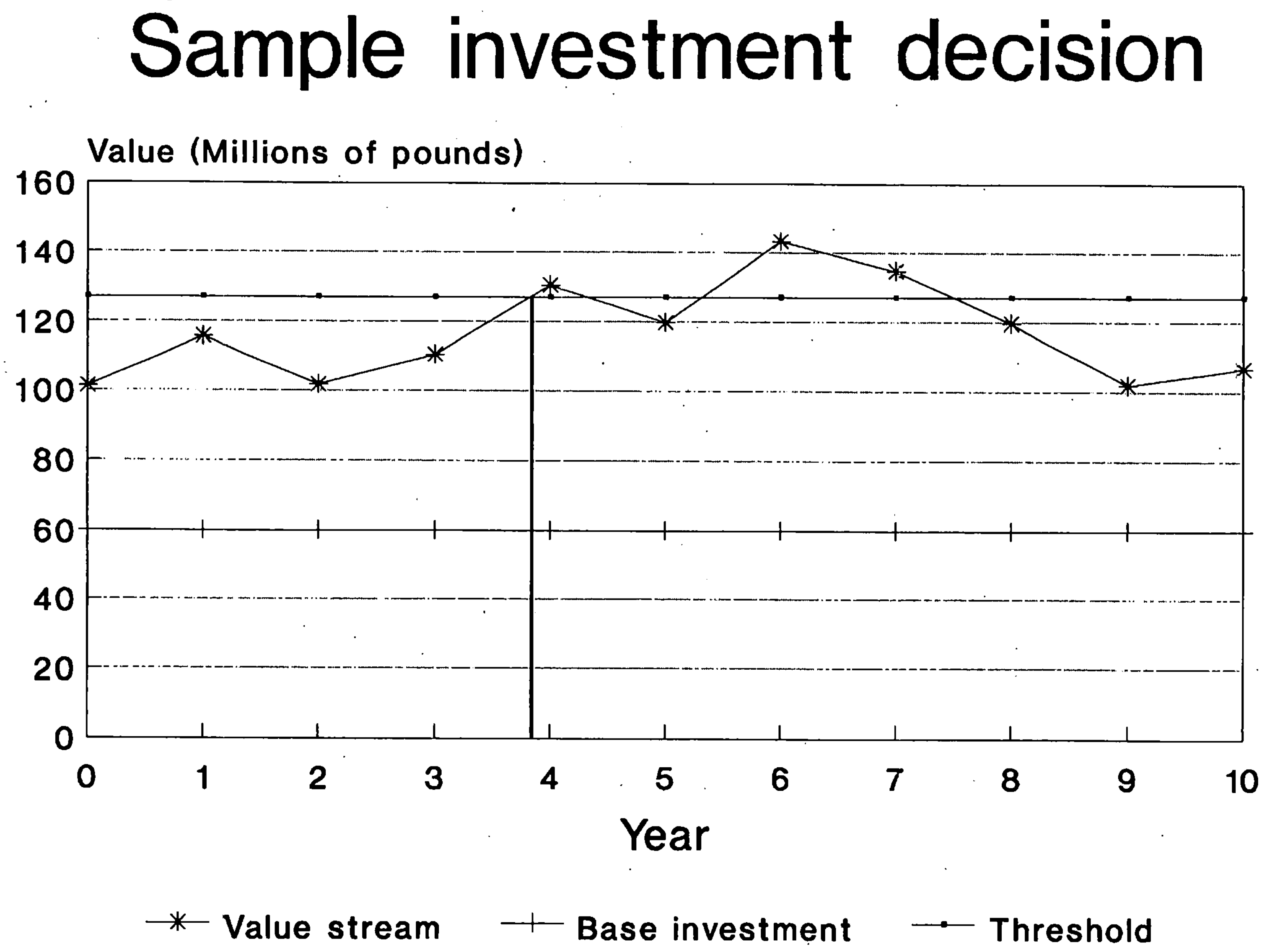
- **Alpha and sigma calculation**. Page C-5 computes the logarithm pairs using the $\alpha$ selected (See equation 4.10). As noted earlier, the user may select three different types of fitting for alpha in the $\sigma$ calculation. In the actual trials in this thesis, the average $\alpha$ across the suite of trials is used in the logarithm pairs. This page then computes the average $\sigma$ used to compute the critical ratio (See page C-6).

- **Output values - main parameters.** Page C-6 incorporates the overall output of the model. It allows the user to select the $\alpha$ fit method, restates the $\alpha$ and $\sigma$ used, and computes $C^*$. The next three variables, Beta 1, R and Delta, are all internal figures used to calculate $C^*$ (See equation 4.5). The threshold value represents the base investment $I$ multiplied by the critical ratio. The string of years and threshold variables reflect the simulation of "reality". The "initial government investment" is the difference between the Year 0 valuation and the threshold value. Figure 5.4 shows a sample printout of the investment opportunity, showing an investment between years 3 and 4; this figure corresponds to Simulation 1 in Table 6.3 in Section 6.2.2.

- **Subsidy cost.** Page C-7 stores the subsidy costs for the volatility minimisation instrument analysis for each trial in the suite (where relevant).

- **Random number generator.** Page C-8 contains an excerpt of the random number matrix. The average figure and standard deviation figures are used to check the shape of the distribution. As noted in Appendix A.5, the algorithm used should produce a set of figures with an average of 0 and a standard deviation of 1. The figures shown on this page have an average of 0.000098 and a standard deviation of .999942, both of which are within acceptable limits.

Figure 5.4:



Sample investment decision
Value (Millions of pounds)
160
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
9
10
Year
Value stream
Base investment
Threshold

- **Macro code.** Page C-9 contains the primary macro code for the simulation model. It generates the random number variables (if not accessed from the library), computes the value series for each trial in the suite, and copies it to the output matrix. The subroutine at the bottom of the page computes the random number matrix based on the algorithm in Appendix A.5, when required.

- **Secondary macros.** Page C-10 contains two simple macros that are used to import and export a matrix of numbers from the random number library, when required .

- **Variables.** Page C-11 contains the cells used by the spreadsheet for the main variables in the macro (e.g. controlling loops, generating the random numbers, etc.).

### 5.5.2 Sensitivity of parameter estimates

To determine the sensitivity of the model to the number of trials used, 10 sets of simulations were run, each with 25, 50 and 100 trials in the suite. Using 100 trials per suite significantly reduced the standard deviation of the average computed $C^*$ across the simulations from 0.730 in 25 trial runs to 0.177 in 100 trial runs (Table 5.3). Based on this analysis, each suite of trials used in the analysis in Chapter 6 contained 100 trials.

Table 5.3:

**SENSITIVITY OF C* ESTIMATE TO THE NUMBER OF TRIALS**

| Number of Trials in Suite | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Average | σ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 2.02 | 2.41 | 1.95 | 2.02 | 4.43 | 1.79 | 2.35 | 2.15 | 1.84 | 2.26 | 2.32 | .730 |
| 50 | 2.23 | 2.34 | 1.95 | 1.97 | 2.70 | 1.87 | 1.88 | 2.11 | 1.99 | 1.83 | 2.09 | .257 |
| 100 | 2.12 | 2.32 | 2.14 | 1.87 | 2.30 | 2.06 | 1.86 | 2.29 | 1.97 | 1.85 | 2.08 | .177 |

### 5.5.3 Potential enhancements to model

This model could be extended to incorporate three additional types of elements, although at the cost of some loss of clarity in the economic analysis of the policy instruments:

- **Depreciation.** The cash flow impact from depreciation typically includes a series of tax benefits, due to the deductibility of depreciation for tax purposes. This effect could be incorporated by deducting the NPV of this "tax shield" from the initial investment $I$.

- **Working capital.** In a typical cash flow model, working capital is assumed to vary directly with the change of sales over successive years. For the purposes of this model, changes in working capital are assumed to be included in the overall sales figures. They could, however, be treated separately.

- **Startup expenses.** Startup expenses may be divided into two types: actual expenses and foregone sales (e.g. due to the short term impact of a plant move on customers' confidence about the company). The NPV of these costs could be incorporated by subtracting them directly from each year's simulation of the cashflow.

## 5.6 Summary

This chapter began by describing how an existing Kodak case example of an overseas plant relocation decision was adapted to model a greenfield investment decision. It then provided a detailed discussion of the computer model built to analyse potential investments, based upon the mathematics and five step process described in the previous chapter. Chapter 6 that follows identifies potential policy instruments and uses this model to assess them.

# Chapter 6

# Potential New Types of Policy Instruments

This chapter applies the mathematical derivations in Chapter 4 and Appendix A to identify a new set of policy instruments, and uses the computer model described in Chapter 5 to test the most promising instrument. Chapter 7 that follows then incorporates the findings of this chapter into a set of recommendations, drawing on the broad themes in U.K. development policy identified in Chapter 2 and the description of corporate investment decision making from Chapter 3.

## 6.1 Designing New Policy Instruments

Using the derivations outlined in the Chapter 4 and Appendix A, it is possible to identify four potential new types of financial instruments

(Table 6.1). These were developed by identifying all variables that impact the critical ratio, based upon the earlier derivations, and then constructing a policy instrument that affected each variable directly. Each instrument was then screened to determine that it had the desired effect and was attractive from a cost-benefit perspective.

The first three potential policy instruments can be identified from the variables in equation 4.5: $\sigma$, $\alpha$ and $r$. The following three types of instruments would affect each of these variables directly:

- **Volatility minimisation instrument.** The first and most promising type of instrument would be for a government to minimize the volatility of a key economic input, such as labour costs or manufactured parts costs (i.e. reducing $\sigma$). Reducing the volatility has the effect of lowering the critical ratio, thereby reducing the amount of additional investment required to push it over the hurdle and shortening the mean time to investment. This can be seen from equation 4.5, since reducing $\sigma$ leads to a larger $\beta$ and therefore to a smaller critical ratio.

- **Trend adjustment instrument.** A second type of instrument would require the development agency to offset the trend in a key input variable (i.e. reducing $\alpha$). For example, if labour costs were rising steadily in real terms, the development agency could agree to offset this increase for a period of 10 years. Reducing $\alpha$ in equation 4.5 leads to a larger $\beta$ and therefore to a smaller critical ratio.

## TYPES OF POLICY INSTRUMENTS

| Term | Source of Term | Sample government actions | Uniqueness of Government Role |
|---|---|---|---|
| $\sigma$ | Equation 4.5 | Make payments to counterbalance changes in real factor costs due to volatility | Moderate-High |
| $\alpha$ | Equation 4.5 | Make payments to counterbalance changes in factor costs due to real cost increases | Moderate-High |
| **r** | Equation 4.5 | Subsidise company interest rates (e.g., soft loans) | High |
| $\Phi$ | Equation 4.13 | <u>**Incumbent Government:**</u> Sign agreements with companies regarding tax policy, etc., or make statements | High, but credibility issues on public statements |
| | | <u>**Opposition government:**</u> Make public announcements regarding proposed policies | High, but credibility issues |

- **Subsidized capital cost.** A common approach used to simulate investment by government agencies is to offer subsidized interest rates (i.e. reducing $r$). This has the effect of reducing the investing company's cost of capital and therefore increasing the NPV. In traditional NPV analysis, this approach has the effect of increasing a company's likelihood to invest. However, the analysis described here presents a counter-intuitive result. Reducing $r$ in equation 4.5 reduces $\beta_1$ and therefore **increases** the critical ratio, thereby reducing a company's propensity to invest. This simple analysis demonstrates that soft loan programs should actually have a **dampening** effect on investment when analysed with a sophisticated investment perspective; they will therefore not be considered further in this research. This result is confirmed by Ingersoll and Ross (1988). They have shown that for long-lived projects, decreasing the interest rate does not necessarily accelerate investment. They also note that reducing a company's interest rate reduces the cost of waiting, and therefore can have at best an ambiguous impact on investment.

The fourth potential type of instrument can be identified from equation 4.13. The three variables described above - $\alpha$, $\sigma$, and $r$ - all appear in this equation, as does a fourth variable $\phi$, which can be used to model the actual or perceived likelihood of a policy shift.[1] Reducing $\phi$ in

[1] $\phi$ can also be used to model other types of external events, such as step changes in exchange rate (e.g. the U.K.'s departure from the ERM), or an oil price discontinuity. This thesis, however, is directed at the **policy implications** of option theory, and therefore

equation 4.13 leads to a lower critical ratio (this may easily be seen by setting $\phi$ to 0), and therefore reflects an increased likelihood for a company to invest. The fourth type of instrument would therefore seek to influence companies' perceptions of the likelihood of different events. This is a somewhat different type of instrument than the three described above, and will be discussed in more detail in Section 6.4.

The following three sections describe each potential instrument in detail and identify their impact on the critical ratio for the Kodak investment decision. Where the proposed instrument is found to encourage appropriate behaviour, the appropriate section then computes the cost-benefit tradeoff from the government's perspective.

## 6.2 Volatility minimisation (VM) instrument

### 6.2.1 Description of potential instrument

The objective of this instrument is to minimise volatility of key factor costs that cannot currently be hedged through traditional financial markets. These would include factor costs such as labour costs and parts costs; other costs such as commodity costs (e.g. oil, gas) and interest costs can already be hedged cost effectively. As will be discussed below, the volatility of these costs can have a significant impact on a company's propensity to invest.

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will not address these types of events further.

Table 6.2: Volatility minimisation policy instrument

| Year | Labour index | Unadjusted Labour cost (Pounds) | Payments Govt. to Co. (Pounds) | Payments Co. to Govt. (Pounds) |
|---|---|---|---|---|
| 1995 | 100 | 10.0 | 0.0 | 0.0 |
| 1996 | 101 | 10.1 | 0.1 | 0.0 |
| 1997 | 102 | 10.2 | 0.2 | 0.0 |
| 1998 | 99 | 9.9 | 0.0 | 0.1 |

The proposed instrument relies upon risk sharing between government and investor, not unlike current government approaches to risk sharing used in tax loss carryforwards and carrybacks. The existence of a number of different financial risk control approaches in the financial markets suggests that this type of approach would be attractive to companies.[2]

Table 6.2 shows how this instrument could work in practice. The government and investing company would begin by agreeing to a suitable index to measure labour cost (e.g. the CSO Quarterly Trend data). A baseline labour cost figure would also be agreed, in this case £10 Million. When the labour index rose above 100, it would reflect an increase in the average cost, and the government would reimburse the company

[2] Many countries (e.g. U.S., U.K.) allow companies to carry back current year operating losses in time, and therefore to claim refunds for taxes paid in the past. Tax losses not used to offset past tax liabilities may then be carried into the future to offset future taxable earnings.

appropriately (i.e. £0.1 million in 1996 and £0.2 million in 1997). If the index were to drop, as shown in the 1998 calendar year, the company would reimburse the government for the difference (£0.1 million). Note that by using this instrument, the company's overall labour cost (i.e. unadjusted plus or minus any payments) remains at £10 million, despite any fluctuations in the labour index. [3]

Although this example is shown on an annual basis, the scheme could be easily implemented on a quarterly basis. "Clawback" provisions parallel to those found in current Regional Selective Assistance programmes could also be imposed (Bachtler, 1990), to ensure that a company was not a net beneficiary of assistance for short term investments (i.e. if the company discontinued operations, it would be required to refund the benefits paid to the government).

The instrument as described assumes an inflation free environment. Implementing it in the real world would require adjustments so that it functioned as if it were in an inflation free environment. In other words, all payments would be based upon figures expressed in real (i.e. inflation free) terms. This conversion introduces the complexity that carryforwards are

[3] Further subtlety could also be incorporated into this instrument. The expected impact of the labour index on the company's actual cost structure could be negotiated. Companies vary considerably in the number of new employees hired each year (which is likely to create a direct "pass through" of the labour market volatility), and are also influenced to a greater or lesser extent by the external labour market in determining how to pay their existing employees. The index used could also be tailored to the specific industry involved.

not usually indexed for inflation.

Majd and Myers (1987) have conducted work in a related area that provides an approach for resolving this issue. In their work, they analysed the impact of tax asymmetries on investment, and found that tax asymmetries can dramatically increase after-tax NPVs for high risk investments. They noted that carryforwards do not typically earn interest, which they must do in order to avoid the creation of an asymmetry. Importantly for this research, they proposed paying interest on tax loss carryforwards as one of several mechanism to correct potential asymmetries. For the volatility minimisation instrument to work in practice, their approach or a similar one would need to be taken. Conceptually, however, it would be straightforward to pay interest on carryforwards based upon published economic data.

An additional important issue is whether this policy instrument creates any credit risk for the government. In fact, the instrument does create a modest credit risk, since it is possible that any given company will go bankrupt at a time when the government has paid a net subsidy up to that point (i.e. the payments over time have not balanced out to their expected average of 0).[4] Two factors minimize the importance of this effect, however. The first is that any financial incentive paid to an investing company creates some risk to the government, and governments have shown themselves

[4]Of course, it is equally possible that the reverse may occur, i.e. the government has been the net beneficiary.

willing to bear this risk. Only in cases of spectacular default is the general public even aware of the subsidy (e.g. the Delorean venture). The second is that the cost here will be lower than paying an outright subsidy, since this instrument seeks only to reduce the volatility of the costs. This instrument should therefore be at least as attractive to regional policy makers and the public as traditional instruments based directly on subsidies.

### 6.2.2 Baseline figures

Having described the proposed policy instrument in detail, it is now possible to use the investment model to identify the impact of the instrument on a company's investment decision. This analysis assumes an initial investment cost $I$ of £60 million. Table 6.3 shows the critical ratio and investment threshold for ten simulations plus an average value across the simulations, prior to any government intervention. Each simulation reflects one potential investment decision.[5]

For each simulation, a critical ratio was computed, based upon the average of 100 trials. Next, the investment threshold was computed by multiplying the assumed initial investment cost of £60 million by the

[5]To clarify terms used in the simulations, a hierarchy of terms was created. At the bottom were the individual **"trials"**. These are the individual runs of the model that are averaged to produce estimates for $\alpha$ and $\sigma$. To produce these averages, 100 trials were combined into a **"suite of trials."** A single **simulation** represented one potential investment decision, i.e. included average parameter values based upon this "suite of trials", plus one forecast of the "actual" behaviour of the investment.

Table 6.3:

**VOLATILITY MINIMISATION INSTRUMENT**

**No Government Intervention**

| | | ***Average Across 100 Trials*** | ***Single Simulation*** | | | | |
|---|---|---|---|---|---|---|---|
| **Simulation** | **Base critical ratios*** | **Investment Threshold** | **Year 0 Value** | **Company Invest in Year ..** | **Government subsidy to stimulate immediate investment** | **Net σ** | **Net α** |
| 1 | 2.12 | 127.2 | 101.2 | 3.8 | 26.0 | 0.272 | 0.0041 |
| 2 | 2.32 | 139.3 | 128.4 | >10 years | 10.9 | 0.240 | 0.0180 |
| 3 | 2.14 | 128.5 | 116.1 | 0.2 | 12.4 | 0.239 | 0.0125 |
| 4 | 1.87 | 112.2 | 88.7 | > 10 years | 23.5 | 0.257 | (0.0053) |
| 5 | 2.30 | 137.9 | 105.6 | > 10 years | 32.4 | 0.292 | 0.0068 |
| 6 | 2.06 | 123.7 | 96.4 | 0.7 | 27.3 | 0.274 | 0.0008 |
| 7 | 1.86 | 111.8 | 85.1 | 6.5 | 26.7 | 0.266 | (0.0084) |
| 8 | 2.29 | 137.3 | 128.0 | 0.5 | 9.2 | 0.235 | 0.0179 |
| 9 | 1.97 | 118.5 | 105.4 | > 10 years | 13.1 | 0.233 | 0.0067 |
| 10 | 1.85 | 110.7 | 94.1 | 1.6 | 16.6 | 0.236 | (0.0009) |
| **Average** | **2.08** | **124.7** | **104.9** | **2.2**** | **19.8** | **0.254** | **0.0522** |

* Suite of 100 trials

** Average of trials where company invested in 10 years or less critical ratio $C^*$. The fourth and fifth columns show the value of the investment computed in year 0 and the time the company would invest with no government investment. The year in which the company would invest can be identified from the simulation runs; this is the point at which the value stream crosses the threshold value (as shown earlier in Exhibit 4.1). A simple linear interpolation was used to identify the point at which the value stream crossed the investment threshold line. The last three columns show the level of government subsidy required to stimulate immediate investment and the net $\sigma$ and $\alpha$ of the overall simulation. The cost for the government to stimulate the investment in year 0 is computed by subtracting the initial valuation from the investment threshold.

The average critical ratio across the ten simulations was 2.08, leading to an average investment threshold of 124.7. The average value of the investment in year 0 was 104.9. For each simulation, this figure was computed by simulating a cashflow stream plus terminal value. This initial value plus the computed average $\alpha$ and $\sigma$ were used to simulate a path for the value of the investment over time. In four of the ten simulations, the company did not invest over the ten year period. This is despite the fact that the naive analysis suggested that immediate investment was appropriate (since in all cases the year 0 value exceeded the initial investment cost of £60 million). In the other six cases, the average time to investment was 2.2 years. The average cost to stimulate investment was £19.8 million.

### 6.2.3 Cost benefit analysis

A similar analysis may be performed with the volatility minimisation instrument in place, to identify the impact on a company's likelihood to invest (Table 6.4). In this case, the government guarantees that $\sigma_{labour} = 0$ and $\sigma_{non-labour} = 0$. This guarantee lowers the critical ratio (from an average of 2.08 to an average of 1.93), leading to a lower threshold value (115.7 vs. 124.7). The average cost of subsidy incurred for each simulation is shown; note that the average is a negative number, i.e. (6.3). In other words, in the simulations shown, the government would achieve a net benefit by putting these measures in place. Simple theory would predict that this number be 0; however, the treatment of bankruptcy in this model has some impact on this average. The model is structured such that if the initial net present value of a sample path simulation is negative, it is excluded from the trial. Negative sample paths are more likely to result from individual cases where one or more of the labour or non-labour costs increases substantially (leading to a net negative profit in some year). However, it is precisely these cases in which the government will on average pay a higher level of subsidy. Excluding them therefore slightly skews the result toward a negative number, i.e. a benefit to the government. Offsetting this potential benefit would be the government's costs of funds in cases where it had a net outflow of funds to different investing companies.

The government's intervention in the investment decision leads to two positive benefits. First, for companies that do invest within 10 years, it

Table 6.4:

**VOLATILITY MINIMISATION INSTRUMENT**

**Results of Government Intervention (Guarantee $\sigma$ labour = 0 and $\sigma$ non-labour = 0)**

| | *Average Over 100 trials* | | | *Single Simulation* | |
|---|---|---|---|---|---|
| **Simulation** | **New critical ratios*** | **New threshold** | **Avg. govt. level of subsidy** | **Company invests year:** | **Government subsidy to stimulate immediate year 0 investment** |
| 1 | 1.93 | 115.7 | <6.1> | 1.3 | 8.2 |
| 2 | 2.16 | 129.8 | <9.4> | > 10 years | 1.0 |
| 3 | 2.11 | 126.3 | <4.9> | 0.3 | 10.3 |
| 4 | 1.62 | 97.2 | <3.2> | 0.8 | 8.1 |
| 5 | 1.87 | 112.2 | <6.8> | > 10 years | 21.4 |
| 6 | 1.79 | 107.2 | <4.1> | > 10 years | 7.0 |
| 7 | 2.02 | 121.0 | <6.8> | 4.6 | 5.4 |
| 8 | 1.96 | 117.6 | <10.2> | > 10 years | 5.5 |
| 9 | 2.09 | 125.6 | <4.9> | 3.2 | 14.7 |
| 10 | 1.74 | 104.2 | < 6.8> | 0.8 | 7.5 |
| **Average** | **1.93** | **115.7** | **<6.3>** | **1.8**** | **8.9** |

* Suite of 100 trials

** Average of investment within 10 or fewer years shortens the average time to investment from 2.2 years to 1.8 years. If companies that do not invest within 10 years are arbitrarily assumed to invest at the 10 year mark, the resulting average time to investment is 5.3 years; putting the instrument in place reduces the mean time to investment to 5.1 years. Second, the average additional incentive required by the government to simulate immediate investment drops from £19.8 million to £8.9 million.

As noted above, the average cost of providing this incentive to the investing company is £-6.3 million across the ten trials. It is useful to assess the theoretical cost as well. Since the labour cost variable is assumed to be a geometric Brownian motion with drift, the **expected** variation due to $\sigma$ is zero, but the **actual** variation can be significant. The government has a unique advantage, however. While a company may make a significant investment only every 5-10 years in a particular market, a development agency routinely oversees these investments. The agency is therefore able to reset the baseline used every year. Suppose one year the index rises. The agency may then need to subsidize a number of investments. In the following year, however, the agency will set the baseline at the higher value. Since there is an equal probability that the index will rise or fall in the third and subsequent years, it will then have the opportunity to recoup its payments. As a result, its average cost will be zero.

Table 6.5 shows how this hedging could work in practice. Suppose the government launches the VM instrument in 1996, when the Labour Cost

Table 6.5:

## GOVERNMENT HEDGING ACROSS MULTIPLE INVESTMENT SUBSIDIES

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|
| Labour Cost Index (LCI) (real terms: corrected for trend) | 1.00 | 1.02 | 1.03 | 1.05 | 1.02 | 1.03 | 1.02 |
| Investment 1 subsidy | ----- | 2.0 | 3.0 | 5.0 | 2.0 | 3.0 | 2.0 |
| Investment 2 subsidy | ----- | ----- | 1.0 | 3.0 | 0 | 1.0 | 0 |
| Investment 3 subsidy | ----- | ----- | ----- | 2.0 | (1.0) | 0 | (1.0) |
| Investment 4 subsidy | ----- | ----- | ----- | ----- | (3.0) | (2.0) | (3.0) |
| Investment 5 subsidy | ----- | ----- | ----- | ----- | ----- | 1.0 | 0 |
| | ------ | ------ | ------ | ------ | ------ | ------ | ------- |
| **Total Subsidy** | 0 | 2.0 | 4.0 | 10.0 | (2.0) | 3.0 | (2.0) |
| | ↑ Investment 1: LCI fixed at 1.00 | ↑ Investment 2: LCI=1.02 | ↑ Investment 3: LCI=1.03 | ↑ Investment 4: LCI=1.05 | ↑ Investment 5: LCI=1.02 | | |

Index (LCI) is at 1.00, and that Investor 1 plans an annual expenditure on labour of £100 Million. Suppose also that the government and investor agree that the LCI index will be set at 1.00. If in 1997 the index rises to 1.02, the government will owe a subsidy of £2.0 Million to the first investor. Note that this is the LCI with any underlying trend removed; this instrument is designed only to minimise uncertainty due to volatility. By analogy with the discussion in Section 6.2.1, the subsidies also need to be adjusted for inflation.

Suppose a second investor with identical characteristics invests in 1997, but the government now agrees with the second investor that the LCI starts at 1.02. Then in 1998, if the LCI rises to 1.03, the government will owe a total of £4.0 million in subsidies; £3.0 million to the first investor $(100 \times (1.03 - 1.00))$ and £1.0 million to the second investor $(100 \times (1.03 - 1.02))$. Note that the total level of subsidy has increased, but less than if the LCI for the second investor were set at 1.00. If a third investor enters the picture in 1998 and the LCI rises to 1.05 in 1999, the total subsidy becomes £10.0 Million, split between the three investors.

In the year 2000, the government sees the first benefit of its ability to hedge its total subsidy cost across investments. Suppose a fourth company enters in 1999, and the LCI agreed is 1.05. Suppose also that the LCI declines to 1.02 (Geometric Brownian motion with drift removed has equal probabilities of rising or falling). Then the government pays out £2.0 million to investor 1, but receives back a total of £4.0 million from investors 3 and 4. Given a large pool of investments, the government subsidy level should average out to 0. Over time, the net subsidy to even a single investment should be 0, but a long run of increases in the LCI could lead to politically unpalatable results (i.e. perceptions of excessive payments to particular companies).

### 6.2.4 Costs and selectivity of VM instrument

Section 2.6 used a simple framework to illustrate the cost and selectivity of different types of incentives. Figure 6.1 arrays the new volatility minimisation instrument on the original Figure (i.e. Figure 2.7). As can be seen, the cost of the instrument is lower than many traditional instruments. The government can therefore implement anything from a highly selective policy to a highly broad policy without incurring significant expenditure.

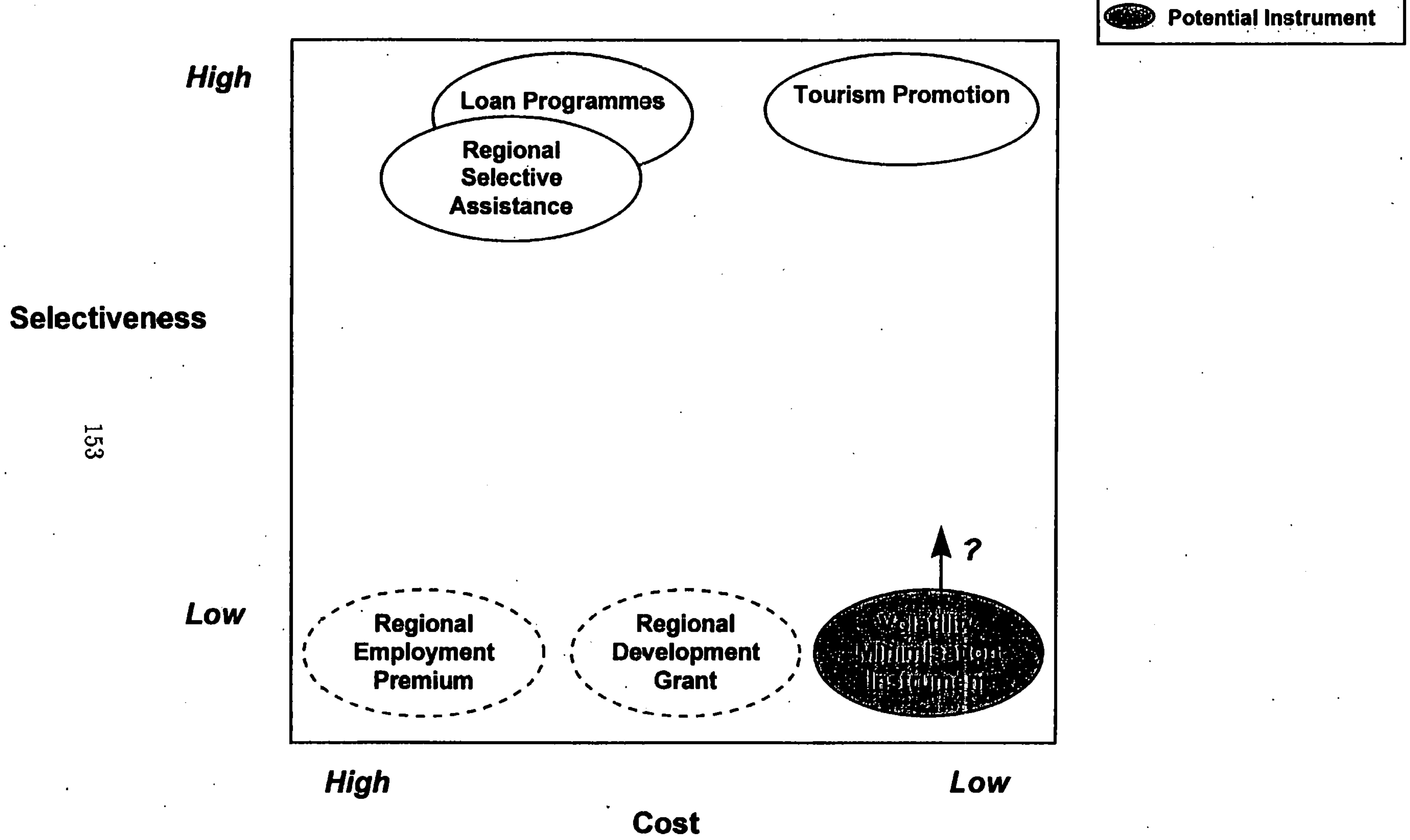
## 6.3 Trend adjustment instrument

### 6.3.1 Description of potential instrument

A second type of new policy instrument would adjust investment risk associated with real changes in key inputs (e.g. parts costs), once the underlying volatility had been removed. To implement this instrument, a development agency would begin by agreeing to a figure for the historic annual trend ($\alpha$) and a base level for a key factor cost, in this case labour cost. The government would then subsidise the labour cost by that amount each year, independent of the actual index (which would show $\sigma$ type

Figure 6.1:

**COST AND SELECTIVENESS OF POLICY INSTRUMENTS (Extended)**



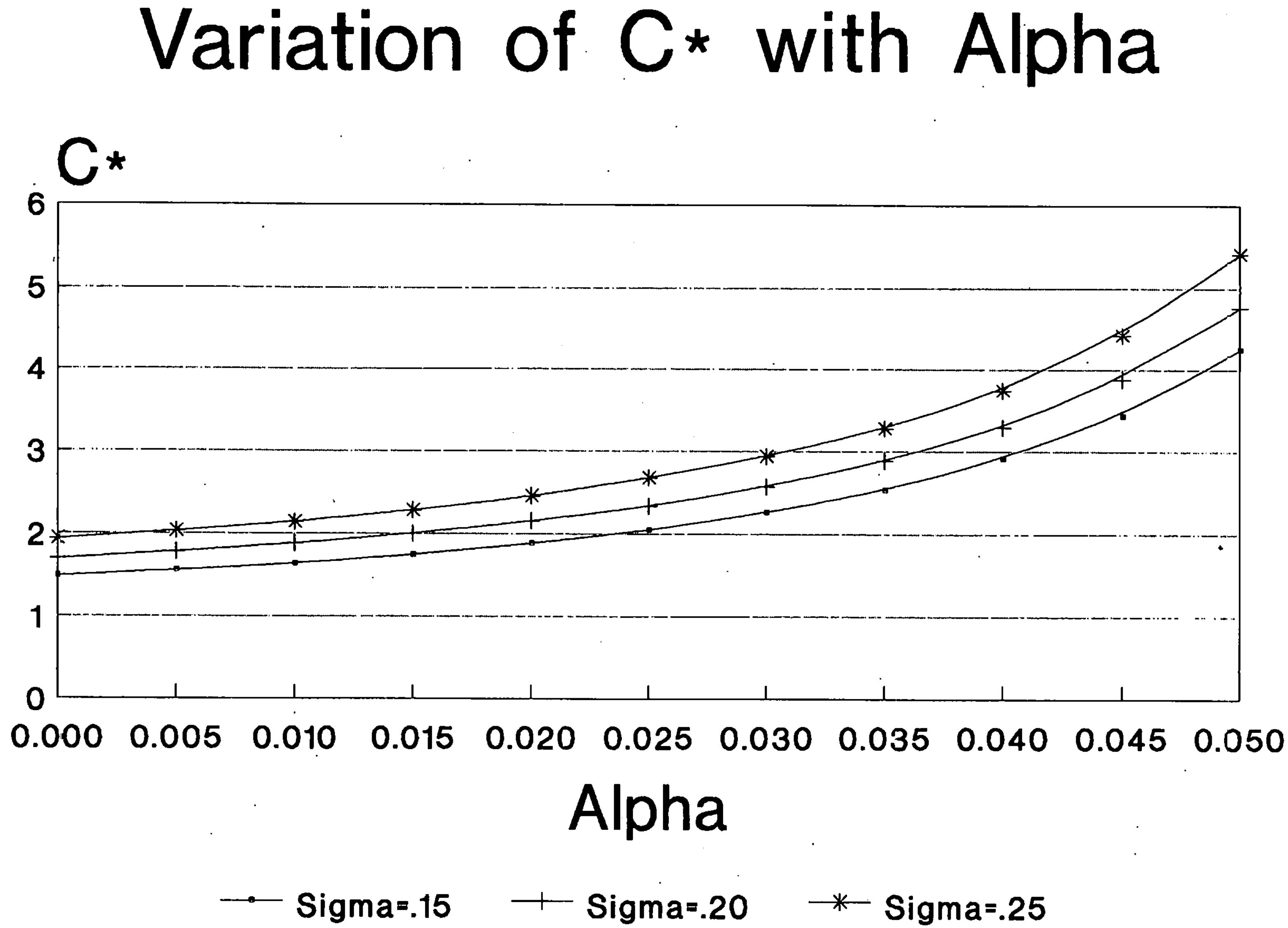
volatility as well). Periodically, the actual trend for the period would be calculated, and any financial adjustments made to ensure that the payments reflect that true trend, not the original estimated one. Note that by taking this approach, the development agency has reduced $\alpha_{labour}$ to zero, which has a significant impact on the critical ratio.

An example of this suggested instrument would be as follows. Suppose that a company has labour expenditures of £100 Million per year, and that the historical increase in real labour rates has been 2 %. Then in the first year, the government would pay a subsidy of £2 million (i.e. $(100 \times 1.02) - 100$), a subsidy in the second year of £4.04 Million (i.e. $(100 \times (1 + .02)^2) - 100$), and so on. To avoid paying out indefinitely, the government and the investing company would agree to a particular period of years for which the subsidy would be paid. Naturally, were the government to implement this approach, it would need to compute that the benefits were sufficient to justify the costs and to agree to a time limit for the subsidy.

### 6.3.2 Cost benefit analysis

Although this instrument is conceptually simple to establish, it has a counterintuitive result that makes it inappropriate to implement. Referring to Figure 6.2, we see the impact on $C^*$ of changes in $\alpha$, for three different levels of $\sigma$. In each case, increasing $\alpha$ leads to increasing $C^*$. However, this $\alpha$ refers to the net **profit** trend of the proposed business. The trend

Figure 6.2:



Variation of C* with Alpha
C*
6
5
4
3
2
1
0
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
Alpha
Sigma=.15
Sigma=.20
Sigma=.25

adjustment instrument described above would level the trend in **expenses** associated with the business. Reducing these expenses increases the profit over time, i.e. leads to higher overall $\alpha$ and therefore an increase in the investment threshold. In other words, providing this apparently sensible incentive would actually reduce the attractiveness of the investment. Only by charging a **premium** on labour or non-labour costs in the future could a government make this incentive work on an economic basis; however, from a policy perspective this is not a viable option. The counter-intuitive nature of this result is similar to the analysis conducted above on the impact of reducing the company's cost of capital, $r$, as noted above. It is also consistent with some of the findings in the literature noted in Section 1.5.

## 6.4 Minimising future policy uncertainties

A third opportunity for government intervention is in the area of reducing future policy uncertainties. This type of potential policy instrument is of a different character than the two described above. Here option pricing can provide insights into two areas:

- From a **company** perspective, it allows us to quantify the impact of policy uncertainty on the critical ratio.
- From a **government** perspective, it allows us to:
  - Identify certain aspects of **optimal policy** for different government parties, given fixed policy parameters related to investment policy (e.g. level of subsidy, approach to minimum

wage). These policy aspects can be identified for each party in both an incumbent and an opposition role.

- Demonstrate how **divergence** of policy between political parties can have a major impact on critical ratios, and therefore on a company's likelihood to invest.

### 6.4.1 Case examples

As a first step in analysing the impact of uncertainty on the critical ratio, I developed two simple scenarios, which can be combined and "inverted" (i.e. the possibility of a tax reduction can be inverted into the possibility of a tax increase). For these cases, recall that the variable $\lambda$ reflects the probability of an event affecting the value of the investment. The variable $\phi$ reflects the percentage change in value of the investment if the event takes place. The two cases analysed were as follows:

**Case 1: Change in Tax Rate**. The first simulation modeled the effect of a 10% chance of a change in corporate tax rate from 33.25% to 36%. Since the post-tax NPV equals the pre-tax NPV times the tax rate, $\phi$ can be determined without any approximation; cash generated by the investment decreases in direct proportion to the change in tax rate. The value for $\lambda$ follows directly from the statement of the case. Computing $\phi$ is easy, since $\phi$ will be the ratio of the difference in after-tax value divided by the original after-tax value, i.e.

$$\frac{33.25 \times \text{ pre-tax value } - 36 \times \text{ pre-tax value}}{33.25 \times \text{ pre-tax value}} = \frac{-2.75}{33.25} = -8\%$$

**Case 2: Change in labour costs.** The second simulation models the impact of a 5% chance of an increase in labour costs due to the imposition of a new minimum wage. Although $\lambda$ follows directly from the definition of the case, $\phi$ requires a little more analysis. Assume that the imposition of a minimum wage results in an increase of 2% in total labour costs. Assume that we are modeling an investment in a labour intensive industry, i.e. labour costs represent 55% of total costs with a profit margin of 10%. The labour index in the simulation therefore increases from 55 in the base year to 56.1, and the base year net profit declines from 10 to 8.9 on an index value basis. The change in $\phi$ can therefore be approximated as:

$$\frac{10 - 8.9}{10} = \frac{1.1}{10} = 11\%$$

### 6.4.2 Description of model

Figure 6.3 shows a printout of the model used to simulate the impact of different uncertainties on $C^*$. The model is based upon equation 4.13 and the method described at the end of section A.3. It has four major parts, as follows:

- **Input parameters.** These include the cost of capital, $r$, the potential volatility of the investment, $\sigma$, and the trend of the investment, $\alpha$. The figures used for $\sigma$ and $\alpha$ are the average values across the ten simulations shown in Table 6.3. The variable $\delta$ is calculated as $r - \alpha$.

Figure 6.3: Printout of uncertainty impact model

Parameters

| | | | | | |
|---|---|---|---|---|---|
| R_val | 0.0700 | | | Uncertainty 1 | Uncertainty 2 |
| | | | Lambda (Prob of event) | 10.00% | 5.00% |
| Delta | 0.0639 | | | | |
| | | | Phi (Shift in value) | 8.00% | 11.00% |
| Alpha | 0.0061 | | | | |
| Sigma | 0.249 | | | | |
| Beta | 2.22780 | Next guess: | 2.22780 | | |
| Value | -0.0000000000 | | | | |
| Adjusted C* | 1.81 | | Base C* | 2.04 | |
| | | | Base beta | 1.96 | |

```
GO      {goto}B15~
        {edit}{esc}1~
        {calc}
        {edit}{esc}+D15~
LOOP    {calc}
        {if B17>-.00000000001}{branch EXIT}
        {branch LOOP}
EXIT
```

- **Uncertain elements.** The model can accommodate two potential random events, and could easily be extended to many more. For each random event, $\lambda$ and $\phi$ are specified, corresponding to the probability of the event taking place and the impact on the value of the investment, respectively. If it is desired to model only one random event in a given simulation, the appropriate $\lambda$ may be set to 0.

- **Iterative variables and supporting macro.** The model uses a seed value and iterates until the error is very small (i.e. $1.0 \times 10^{-11}$). The spreadsheet macro shown at the bottom of the page automates this process.

- **Output values.** There are two key outputs of this model. The first is the new critical ratio, reflecting the uncertainty about the future. The second is the critical ratio without any uncertainty (i.e., with both $\lambda$s set to 0).

### 6.4.3 Results of simulations

Using the scenarios and the above model, the numerical approximation approach described in equation 4.13 was used to determine the change in $C^*$ and therefore the increase in investment threshold for a total of eight examples. As noted earlier, the average $\sigma$ and average $\alpha$ from ten simulations in Table 6.3 were used to compute the critical ratio used in these examples. Table 6.4 summarizes the results. All of these examples assumed that the required level of investment, $I$, was £60 Million.

Figure 6.4: Impact of uncertainties on the critical ratio

| Example | Potential Event | Base C* | New C* | Increase (decrease) in Threshold: £ Millions |
|---|---|---|---|---|
| 1 | Increase in corporate tax rate | 2.04 | 1.90 | (8.4) |
| 2 | Decrease tax rate | 2.04 | 2.26 | 13.2 |
| 3 | Increase in labour costs | 2.04 | 1.94 | (6.0) |
| 4 | Decrease in labour costs | 2.04 | 2.19 | 9.0 |
| 5 | Increase in tax and labour costs | 2.04 | 1.81 | (13.8) |
| 6 | Increase in tax/reduction in labour costs | 2.04 | 2.00 | (2.4) |
| 7 | Decrease in tax/increase in labour costs | 2.04 | 2.12 | 4.8 |
| 8 | Decrease in tax and labour costs | 2.04 | 2.45 | 24.6 |

The results for each of the eight examples are as follows:

- **Case 1.** A possible increase in the corporate tax rate lowers the critical ratio from 2.04 to 1.90. This reflects a company's increased interest in investing today if it feels that there is a possibility of a tax increase in the future (in order to secure the benefits of the project when the tax rates are lower). By investing today, it foregoes the opportunity to learn more about the future; however, the income stream available at a lower tax rate more than compensates for this foregone opportunity.

- **Case 2.** A possible decrease in the tax rate has the reverse effect, raising the threshold from 2.04 to 2.26.

- **Cases 3 and 4.** In case 3, a possible increase in labour costs has a similar stimulating effect as a possible negative change in the corporate tax rate did in case 1. In case 4, the possibility of a reduction in labour costs tends to delay investment today.

- **Case 5.** This case combines the effect of two potential negative events, i.e. cases 1 and 3. The critical ratio decreases by nearly exactly the sum of the decreases from the individual cases, resulting in a sharply lower critical ratio (and correspondingly stronger motivation to invest today).

- **Cases 6 and 7.** These two cases combine the possibility of one positive and one negative event. The net impact on the critical ratio depends on which event has a larger impact on the critical ratio in isolation. In these cases, the possibility of an increase in the corporate tax rate dominates.

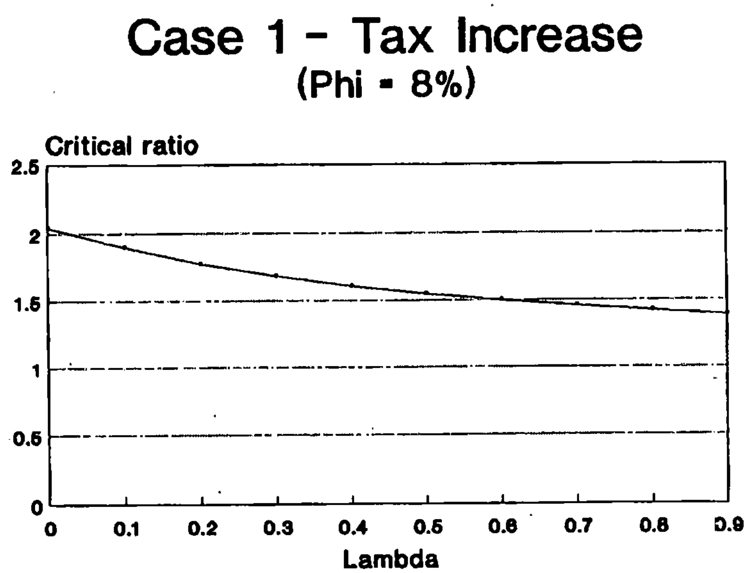
- **Case 8**. The final case combines the possibility of two positive events. In this case, the change in critical ratio is somewhat larger than the sum of the impact from the two in isolation. For example, if there are multiple uncertainties in connection with a change of government, and the business community feels that they will all be positive, it will have a depressive effect on investment in the short term. This "loads the dice" strongly against an incumbent government with even slightly less "business oriented" policies than the opposition. In this case, the possibilities reflected were a small increase in the tax rate and a moderate effect from the imposition of a new minimum wage.

It is important to note that these results apply equally to changes resulting from a change of government or a policy shift by the incumbent government. While the former type of uncertainty is an inevitable byproduct of a democratic society, the latter is under the direct control of the incumbent party. Managing this potential source of uncertainty should be a priority for all political parties. As Aizenman and Marion (1991) have noted, "The new wisdom is that it may not be enough to set macroeconomic policies at the 'right' levels. Uncertainty about the future course of policies should also be minimized." The large impact of small probabilities of adverse events on the critical ratio reinforces their finding of the need for any government to minimize uncertainty about its own course of policies. It also underscores the potential detrimental impact of opposition party attacks on the sustainability of current policies. This result is confirmed in Pindyck (1991) who notes "... if a goal of macroeconomic policy is to stimulate investment, stability and credibility may be more important than the particular levels of tax rates or interest rates."

Using the model, two additional sets of analyses were conducted. The first examined the impact of increased likelihood of the adverse events described in the two cases above (i.e. a potential tax increase or a potential labour cost increase). Figure 6.5 summarizes the results. As expected, increasing $\lambda$ lowers the critical ratio, increasing a company's likelihood to invest in the short term. This is because as the probability of an adverse effect increases, a company will seek to maximize its returns today to gain the benefits of the higher short term profits.

A second set of analyses sought to validate and quantify the impact of policy divergence as noted by several authors and discussed in Section 1.5. Here the probability of an adverse event was kept constant, but the expected magnitude of the event (the variable $\phi$) was varied between 0% of the total value and 40% of the total value. As expected, and predicted by other research, the critical ratio decreased somewhat with increasing $\phi$ (See Figure 6.6). This is because as potential future events become more onerous, a company will be more motivated to invest today.

Figure 6.5: Impact of increased uncertainties



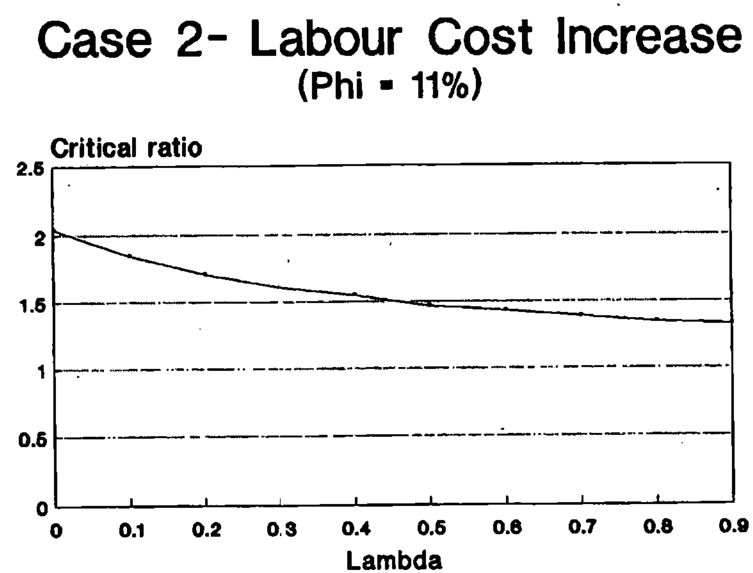
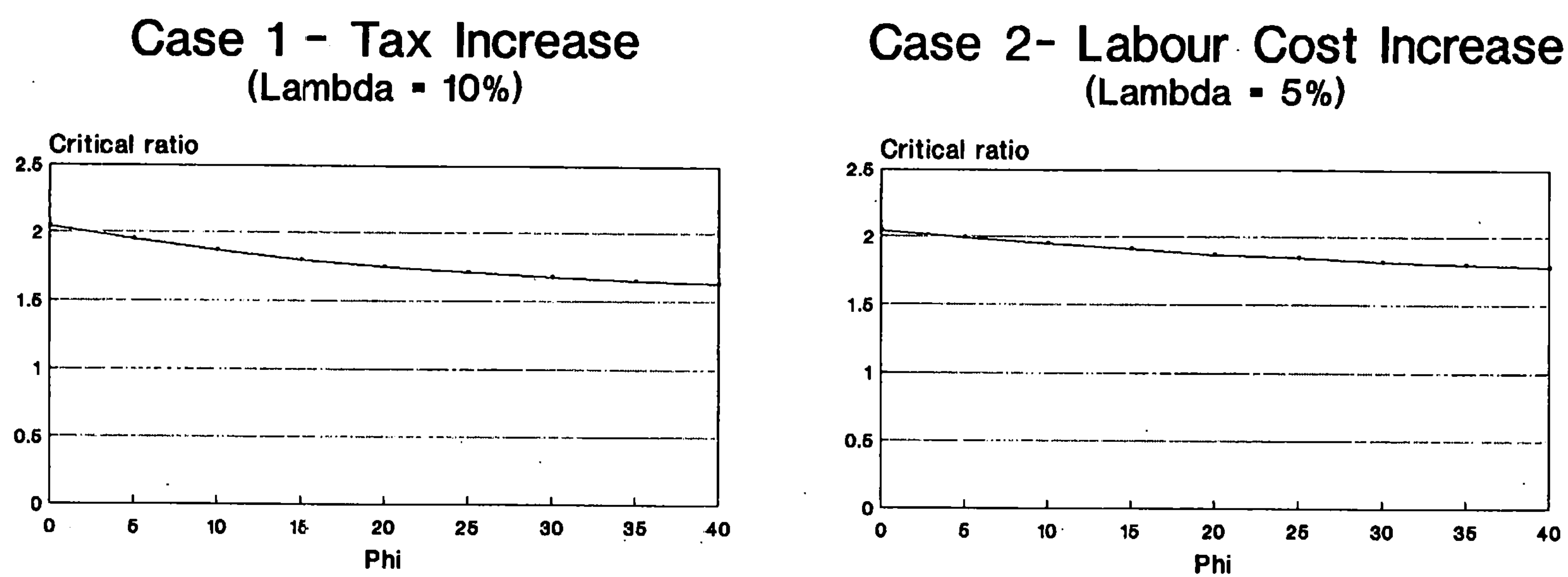



Figure 6.6: Impact of policy divergence on critical ratio



While this result is important on its own, there is also a "multiplier effect" that amplifies it. Since the critical ratio is multiplied by the investment cost to determine the threshold level, a small change in the critical ratio can lead to a large increase in the absolute dollars required to stimulate investment. If a government is trying to "make up the difference" (see for example Table 6.3), a small shift in $C^*$ can have a significant impact on the investment promotion budget.

### 6.4.4 Modeling different FDI policies

In order to distil the policy implications from this mathematical approach, I have applied the above logic to government policy on inward investment. In doing so, I have simplified the real world considerably. Going forward, it will be assumed that there are only two parties, a strongly free market oriented party ("Free market" party) and a party which gives greater priority to social concerns ("Social contract" party); the existence of a third party will not be considered. It will also be assumed that the tax rate under a "Social contract" government will be slightly higher than under a "Free market" government.[6]

[6]It will not escape the reader that these party descriptions bear some relation to the two largest political parties in the U.K. The models presented here, however, are a sufficient abstraction from reality that to identify them as real parties would not do justice to the range of concerns either party considers. Nonetheless, even this simple abstraction from reality produces some important insights about FDI policy and its communication in a democracy, as will be seen below.

The analysis that follows is consistent in light of different assumptions. So long as the "Social contract" government's spending priorities result in even a small additional cost to the investing company (e.g. through increase in the level of the minimum wage, higher VAT leading to decreased sales, etc.), the policy prescriptions made below hold true.

### 6.4.5 Optimal policy strategies for incumbent and opposition parties

Figure 6.7 summarizes optimal actions for both incumbent and opposition parties, assuming that the policies of a "Social contract" government results in at least slightly lower corporate profits. The analysis assumes that each party has broadly fixed investment policies based upon the assumptions made above, but nonetheless wishes to optimize its own position. A government in opposition is assumed to benefit politically from a lower level of investment, in that it gains a political advantage relative to the incumbent. An incumbent government is assumed to benefit from a high level of current investment. In reality, of course, the actual situation is more complex, but these assumptions will be made in order to model the situation and to gain insight. It should also be noted that each party is assumed to have equal "self-interest" in this respect.

This analysis yields a number of conclusions, some intuitive and consistent with current practices, and some not. Specific conclusions for each situation are as follows:

Figure 6.7:
**OPTIMAL ACTIONS FOR INCUMBENT AND OPPOSITION PARTIES**

☐ **Counterintuitive results**

| | **Strong Free Market Approach** | **Social Contract Approach** |
| --- | --- | --- |
| **Incumbent** | • Encourage balanced discussion of opposition policy in key areas (e.g., through constructive debate in Houses of Parliament)<br>• Avoid guarantees /special provisions for investments in the future | • Attack credibility of opposition promises on investment policy<br>• Match likely opposition incentives in targeted industries (where no great impact on **overall** policy) |
| **Opposition** | • Publicise improved business opportunities under free market approach<br>• Suggest opposition policies likely to change/are ambiguous | • Suggest opposition policies likely to **change** due to e.g., budget constraints |

- **Incumbent "Free market" government.** The incumbent "Free market" party should seek to capitalize on its slightly more business oriented policies (e.g. companies are more likely to invest if the tax rate is lower). It can do this in two ways:
  - The first action is to **encourage balanced discussion** of the "Social contract" party's policy approach. The key word here is balanced: acrimonious debate is unnecessary and is likely to weaken the credibility of the "Free market" party. This step reinforces companies' desire to invest today.
  - The second action is to **avoid making guarantees about the future.** Ironically, suggesting that current policies will remain forever, or even signing agreements on specific incentives for a future date, has a strongly depressive effect on investment (by removing or reducing the risk of an investing company created by waiting to learn more about market conditions in the future). This is not an intuitively obvious result, but an important one.
- **Opposition "Free market" party.** The "Free market" party in opposition will have an advantage relative to incumbent "Social contract" party, in that some potential investors may wait until a change of government to reap the benefits of a more beneficial business climate. This advantage holds true only if opposition party claims are credible (credibility is important, because it is the **perceived likelihood** of events that will influence a company's likelihood to invest). The "Free market" party in opposition can take

two specific actions to maximize its effectiveness:

- The first action is to **attempt to build awareness of improved future opportunities** under the "Free market" party's government. This is a typical behaviour, but will be successful only if its claims are credible.
- The second action is to **suggest that the policies of the "Social contract" party are likely to change.** This creates further uncertainty about the future, depressing a company's likelihood to invest today (e.g. through increasing the $\sigma$ of the overall investment and thereby increasing the critical ratio). This approach is not generally followed today. Rodrik's (1990) studies on major structural reform in developing countries has confirmed this principle. He notes, "rational behavior by the private sector calls for withholding investment until much of the residual uncertainty regarding the eventual success of the reform is eliminated." This finding applies to the U.K.: firms will strongly and appropriately prefer to have uncertainty regarding policy reversals resolved before making significant investments. Either opposition party has the potential to limit short term investment levels by challenging the sustainability of current policies of the incumbent government (while recognising that this is clearly not in the country's best interests).

- **Incumbent "Social contract" party.** As noted earlier, an incumbent "Social contract" party faces a disadvantage, in that some companies will conduct an analysis similar to the one discussed in Section 6.4.1 and conclude that they should wait until a change of government before making additional investments to reap the benefit of slightly lower tax rates (this analysis holds equally for domestic and foreign investing companies). Assuming that the "Social contract" party seeks to maximize investment in the short term to create job opportunities, it should take two actions:

- **Attack credibility of "Free market" party promises** to improve financial policies for investors. This is a standard approach, and relies (correctly) on the result that if companies are persuaded that the benefits of a different government are likely to be smaller than expected, a significant deterrent to investing today can be avoided. A similar line of reasoning applies if uncertainty can be created over the **probability** of improvements to the general business climate.
- **Match "Free market" party incentives in targetted industries.** This is not often followed in practice, but could be very effective. By removing the uncertainty about the future, the "Social contract" government "levels the playing field" in specific industries without doing violence to its overall policy.

• **Opposition "Social contract" party.** On the margin, either party in opposition will benefit from delays in investment (i.e. because it will be able to suggest that its policies were directly responsible for the new investment when it is made later). The "Social contract" party in opposition should therefore suggest that the "Free market" party's policies are unsustainable (e.g. because of budget constraints, demographic trends). Since it will not be obvious how the policies will change, it will tend to increase the uncertainty about the future, and therefore increase the critical ratio. It is important to note that this is a subtle but important departure from a popular approach of attacking the policies directly (e.g. on grounds of effectiveness, fairness, fit with European policies).

## 6.5 Summary and conclusions

This chapter has drawn upon the mathematical analysis and the Kodak model developed in Chapters 4 and 5, respectively, to identify and screen a potential new set of policy instruments. It has identified one instrument, the Volatility Minimisation (VM) instrument, which has a strongly encouraging effect on investment levels and can be implemented at low cost to the government. It has also identified a number of behavioural implications for both Incumbent and Opposition political parties related to minimising future policy uncertainties.

Chapter 7 that follows identifies the final policy recommendations. It draws some general conclusions and presents detailed action steps to implement the VM instrument on a pilot basis. It also compares the VM instrument with recent investment policy approaches to assess it for reasonableness. Lastly, it provides a few insights into the implications of this analysis on corporate investment decision making.

# Chapter 7

# Summary and Implications for Development Policy

## 7.1 Summary of methodology

This thesis has drawn together several disparate areas of research to identify new policy levers to promote inward investment. It began by reviewing the U.K.'s regional policy objectives in Chapter 2 and typical approaches to corporate decision making in Chapter 3. Chapter 4 provided a brief summary of net present value analysis (the most popular methodology for corporate investment decision making), and showed how this approach could be improved by applying research findings by McDonald and Siegel (1986) and Dixit and Pindyck (1994). In Chapter 5, this thesis described the creation of an analytical model based upon fieldwork with Kodak and the mathematical approach described in Chapter 4.

Chapter 6 then drew upon these analyses to identify a comprehensive set of policy levers to stimulate inward investment and developed a potential policy instrument for each. Each of the four potential instruments was screened for its encouragement of the desired behaviour (i.e., the policy instrument should encourage more rapid investment, or it should reduce the level of subsidy required). The first instrument - minimising the volatility of key inputs - was found to encourage the desired behaviour on the part of the investing firm and to be extremely cost effective to administer. A second instrument - controlling the uncertainty created by policy pronouncements by the incumbent and opposition governments - was not a policy instrument in the same sense as the other three, but nonetheless provided some important insights into the optimal behaviour of incumbent and opposition parties. The remaining two potential instruments - providing soft loans and minimising the risk of a real increase in key elements of a company's cost structure - were found to encourage the **opposite** behaviour of what was intended, and therefore were not considered further.

The remainder of this chapter identifies a set of recommendations to investment policy makers. In particular, it suggests adoption of the Volatility Minimisation (VM) instrument described in Chapter 6. To check that the VM instrument is consistent with recent themes in U.K. investment policy, this chapter assesses the coherence of the proposed instrument with the key regional and investment policy issues identified in Chapter 2. It also makes some additional recommendations regarding investment policy pronouncements by the incumbent and opposition parties. It concludes with a few recommendations for corporate investment decision makers that result from this analysis.

## 7.2 Recommendations for U.K. inward investment policy

Based upon the research in this thesis, development agencies should undertake a number of specific initiatives (see Figure 7.1 for a summary). The specific initiatives are as follows:

- **Refocus mindset of development agencies towards minimising investor uncertainty.** After years of regarding their role as facilitating foreign investment through "sweeteners", it will require a significant mindset change for these agencies to recognise and exploit the role that uncertainty plays in investment decision making. This recommendation could be implemented in parallel with encouraging stronger DTI support for investment in general. The 1992 Coopers & Lybrand study found that "although companies were not specific about the nature of the support they required, publicity, long term investment and training were the most common subjects of requests for action by the DTI in the future."
- **Pilot volatility minimisation instruments**, developed nationally and negotiated locally. Drawing upon this research, pilot schemes in one or more regions should be launched. These should aim to implement a volatility minimisation approach for one or two

Figure 7.1:

# OVERALL RECOMMENDATIONS

## *Policy Recommendations*

**Volatility Minimisation Instrument**

- Refocus mindset of development agencies towards minimising investor uncertainty
- Pilot volatility minimisation policy instrument, analysed centrally and negotiated locally (e.g., in priority geography or industry)
- Build centralized consultancy unit to advise regions and development agencies on costs and likely benefits of volatility guarantees in local negotiations
- Aim for substitution of grants/fiscal aid by volatility guarantees wherever possible

**General Recommendations**

- Scottish Enterprise, WDA, and IBB to update advertising to emphasise policy and economic stability of country and regions (as proxy for $\sigma$), rather than just financial incentives
- Political parties should minimise attacks on substainability of opposition policies (i.e., to further national interest)

## *Corporate Recommendations*

- Build capabilities in finance organization to analyse investments under uncertain conditions
- Negotiate incentives more aggressively based on "new" thinking (i.e., to reflect higher investment thresholds, opportunity, for non-traditional incentives)
- Improve analysis of cross-site comparisons to fully reflect volatility and uncertainty of each location

mid-sized companies in two or three regions. It would then be possible to leverage the experience from these pilots to develop a national roll-out plan.

- **Build centralized consultancy unit** to advise regions and development agencies on the likely costs and benefits of volatility minimisation incentives in local negotiations. Given the specialized nature of the expertise required and the relatively high cost of the required employees, this unit should be centrally located and made available on a consultancy basis to the pilot scheme.

- **Aim for substitution of grants/fiscal aid by volatility guarantees** wherever possible. Given the low cost of implementing VM instruments, as shown in Section 6.2.3, there may be significant opportunity to replace expensive subsidies with factor cost volatility and policy uncertainty guarantees. Soft loans, in particular, should gradually be phased out as a policy instrument, given their tendency to **delay**, rather than accelerate, investment when properly analysed (See Section 6.1).

- **Regional development agencies to update advertising** to emphasise policy and economic stability of individual regions and the U.K. as a whole. These agencies (i.e. the Invest in Britain Bureau, Welsh Development Authority and Scottish Enterprise) often emphasise the underlying attractiveness of **current** costs and economic factors. Focusing instead on the U.K.'s relative stability over the medium to long term will actually have a greater impact in accelerating inward investment.

- **Political parties should minimise attacks on the sustainability** of opponent's policies. Given the potential for damage to the national interest of attacks by one party on the sustainability of the policies of the others, it is important that the parties form a tacit or explicit agreement not to attack one another in this way.

## 7.3 Coherence of volatility minimisation instrument with recent policy

This section compares the consistency of the recommendation to implement a volatility minimisation instrument with the five major types of conclusions summarized at the end of Chapter 2. The types of conclusions were general regional policy objectives, investment policy objectives, investment policy instrument emphasis, approach to investment incentives and approach to avoiding excess competition for investment. This section concludes with a brief discussion of the volatility based instrument in relation to the old Regional Employment Premium (REP).

### 7.3.1 General regional policy objectives

The summary at the end of Chapter 2 identified several long-standing themes in regional policy objectives. These were the continuing need for regional intervention, the long-standing belief by both parties that inward investment should be encouraged and the government's willingness to experiment with innovative approaches. There was also a fourth theme of traditional emphasis on automatic aid that was not likely to continue. Of these, three are most relevant to the implementation of a volatility based policy instrument:

**Encouragement of inward investment.** The U.K. has adopted a very encouraging stance, in particular with respect to Japanese investment (see for example, Strange, 1993). Implementing the volatility minimisation instrument described here would support the U.K.'s encouraging stance, but at very low cost.

**Willingness to experiment with innovative approaches.** The U.K. has shown willingness in the past to experiment with novel approaches, which suggests that it is not unreasonable to imagine that it might adopt this new policy instrument.

**Automatic versus discretionary aid.** The low cost of the volatility based instrument suggests that it may be offered on an automatic basis. Pfeffermann's (1992) brief survey of recommendations to stimulate investment encourages emphasis on automatic aid, since discretionary aid "wastes time, adds uncertainty and invites corruption."

### 7.3.2 Investment policy objectives

The summary at the end of Chapter 2 noted that primary job creation and capital investment were the two most important objectives, followed by stimulus for domestic industry, secondary job creation, encouraging particular industries and encouraging the eventual transfer of other corporate functions. The volatility minimisation instrument would stimulate investment equally in capital intensive and human intensive industries (although the exact guarantees agreed between the company and the government would reflect the people or capital intensivity of the business), and therefore would be consistent with recent policy objectives.

### 7.3.3 Fit with policy instrument emphasis

Chapter 2 concluded that in the area of policy instrument emphasis to encourage investment, the government has given primary emphasis to financial incentives, followed by decentralisation of government offices, creation of regional development agencies, regional allocation of public investment and government orders, and infrastructure aids. Disincentives have not been used effectively since 1981 as a policy lever. Implementing the volatility minimisation instrument would follow the government's traditional emphasis on financial incentives.

### 7.3.4 Approach to investment incentives

As noted at the end of Chapter 2, some broad generalisations may be drawn about the type of incentives preferred by the government in recent years. These include emphasis of grants over tax incentives or labour subsidies, introduction of broader support to businesses (e.g. provision of consultancy services), limited application of industrial policy, and equal treatment of inward and domestic investment. It was also noted that local authorities have a significant role in influencing local investment decision making. The chapter also discussed the relative cost and selectivity of particular incentives. It concluded that the ideal instrument would be low cost to administer, but leave some flexibility in how selectively the government chose to adopt it. All of these issues are relevant to the implementation of the volatility minimisation instrument, as follows:

**Grants vs. fiscal aid or labour subsidies.** Many authors have noted the inherent attractiveness of labour subsidies relative to investment grants (e.g. Brech and Sharp, 1984, Vanhove and Klaasen, 1986). The implementation of volatility minimisation based instruments follows this preferred approach of providing subsidies to labour, but at a far lower cost than some of the approaches used in the past (e.g. the Regional Employment Premium).

**Provision of consultancy services.** While the government's consultancy services have traditionally been more strategic or operations focused, the analysis required to negotiate the details of the volatility minimisation instrument will generate a perspective on the risks faced by the investing enterprise. This analysis has significant value, over and above the benefits provided through making the VM instrument available.

**Limited application of industrial policy (i.e. targeting of particular industries).** Given the very low cost to administer the instrument, it is not necessary to be selective in its implementation. The government can therefore continue its approach of giving limited emphasis to industrial policy.

**Equal treatment of inward and domestic investment.** Since aid to industry is usually considered a fixed dollar "pie", aid to domestic versus inward investment is generally regarded as a "zero sum game" (i.e. assisting one company requires reducing potential assistance to another). Volatility-based instruments are low cost to implement, and therefore there is little need to discriminate between these two sources of investment. Pfeffermann (1992) recommends treating foreign investors equally with domestic ones, to avoid being unfair to national entrepreneurs and to avoid encouraging questionable joint ventures (e.g. ones where local parties are sought only to qualify for incentives).

**Regional versus local decision making.** Individuals with the skills required to support adoption of the VM instrument (e.g. mathematical economists) are relatively expensive, and therefore should be centrally located and managed to avoid duplication across different regions. The actual negotiations, however, will require detailed knowledge of local conditions, and therefore should be conducted at a local level. This balance of regional and local authority is consistent with recent history.

**Selective incentives versus broad based incentives.** The low cost of the volatility minimisation instrument (i.e. administration only) suggests that it may be offered broadly. Figure 6.1 from the previous chapter shows that this instrument is on the ideal part of the cost/selectiveness matrix. It is very low cost, and can therefore be applied as selectively or comprehensively as desired.

### 7.3.5 Impact on competing for investment

Section 2.7 provided a brief summary of the EC caps on investment incentives, in the very narrow context of how these caps were intended to prevent destructive competition for investment between regions. The volatility minimisation instrument can easily be implemented in all regions; indeed, its low administration cost and stimulating effect on investment suggests that it should be widely adopted. Its adoption raises the possibility that the VM instrument might encourage even greater competition between regions and countries for investment.

Two important factors mitigate this tendency, however. Since the negotiations are conducted based upon local conditions, it will be more difficult to make explicit comparisons between one region and another. This tends to "decommoditise" the investment decision, which works to the benefits of all regions. Second, for a company to consider a site seriously where VM instruments are available, it must make considerable effort to understand the local region and to model the economics. This in turn requires an investment of scarce internal skills, limiting the number of sites that can be considered. Despite these mitigating factors, the potential for bidding for investment continues, and therefore the U.K. should continue to support the concept of EC limits.

### 7.3.6 Comparison with Regional Economic Premium

The proposed VM instrument captures a number of the benefits of the REP, but at far lower cost. Section 2.5.3 identified seven benefits of the REP:

1. It provided a local labour cost advantage.
2. It avoided the capital orientation of many investment programmes.
3. It did not discriminate against existing firms.
4. It gave special encouragement to labour intensive types of industry.
5. It cut regional production costs (like a regional devaluation).
6. It minimised the spreading of effects to other regions.
7. It incorporated an income transfer from rich to poor regions.

The new instrument does not provide a local labour cost advantage (benefit 1), but does stimulate investment in the regions where it is in place. It can be used equally well in capital or people intensive industries, and therefore provides benefits 2 and 4. As conceived, it does discriminate against existing firms (benefit 3) - although the approach could be extended to existing firms in depressed regions. It does not cut regional production costs directly or build in an income transfer (benefits 5 and 7), but it does minimise spreading effects to other regions (benefit 6), so long as the government controls its application.

While the volatility minimisation instrument does not provide all of the benefits of the REP, it does provide a number of important benefits at very low cost.

## 7.4 Potential impact on corporate decision making

While making recommendations for company decision makers is not the focus of this thesis, it is possible to identify a few top level conclusions (see the right hand side of Figure 7.1). These include:

- **Build capabilities in the Finance organization to analyse investments under uncertain conditions.** At any given point in time, corporations are using a wide variety of approaches to analyse potential investments (See, for example, Schall et al, 1978, Klammer, 1972). The general trend over the last 50 years, however, has been for companies to adopt increasingly sophisticated approaches (e.g. from simple payback calculations to sophisticated Net Present Value analyses). For companies to adopt the new type of thinking described here is the next logical step in this progression. Given the potential importance of uncertainty based analytical tools in making good investment decisions, companies should accelerate any existing efforts to develop the required skills. They should also ensure that their decision making approach is as "rational" as possible, given some of the pitfalls described in Chapter 3.

- **Negotiate incentives more aggressively based on "new" thinking.** There is no reason why companies cannot take the lead with development agencies in seeking to apply the volatility minimisation based approach. The government should be more receptive to this approach than requests for further subsidies or tax incentives, given the low cost to implement the program.

- **Improve the analysis of cross-site comparisons** to fully reflect the volatility and uncertainty of each location. Companies need to apply the analytical approaches described in this thesis to each major investment decision, to ensure that the timing of the investment yields the optimal results. This will require much greater focus in site selection; traditionally, companies have been able to consider a large number of sites by "playing off" one particular region against another. In the new world, a company will require more detailed analysis to consider any site (e.g. to understand local factor cost trends in detail), and therefore will need to consider fewer sites. This should lead to a better balance of power between investor and receiving location; the main beneficiary will be the receiving region.

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# Appendix A

# Mathematical Formulas and Derivations

This appendix describes and extends slightly work set forth by McDonald and Siegel (1986) and discussed further in Dixit and Pindyck (1994). The mathematical notation used follows the latter source. Section A.1 sets out some notation on Brownian motion and Wiener processes. Section A.2 re-derives the optimal investment point for a single stochastic variable. Section A.3 re-derives the investment decision rule for a single Poisson process. Section A.4 extends this analysis to multiple dimensions and states the general rule for combined stochastic and Poisson processes. Section A.5 describes the algorithm used for generating random numbers with a normal distribution.

## A.1 Analytical background

This analysis will rely heavily upon functions that describe Geometric Brownian motion with drift. A typical exogenous variable such as interest rates can be modeled using equations in the form:

$$dx = \alpha x dt + \sigma x dz, \tag{A.1}$$

where dz is the increment of a Wiener process. In other words, $dz = \epsilon_t \sqrt{dt}$, where $\epsilon_t$ has zero mean and standard deviation of 1. Then $\mathcal{E}(dz) = 0$, a result that we will use frequently in this analysis. In equation A.1, $\sigma$ refers to the volatility of the variable and $\alpha$ the increase (or decrease) over time. If the current state of the variable is included (e.g. today's interest rate), then these two parameters can be used to predict future values.

Ito's Lemma, otherwise known as the fundamental theorem of stochastic calculus, provides a way to differentiate functions involving Wiener processes. If we generalize the expression for $dx$ in equation A.1, we have:

$$dx = a(x,t)dt + b(x,t)dz \tag{A.2}$$

If we assume that $F(x,t)$ is at least twice differentiable in $x$, and once in $t$, then Ito's Lemma may be stated as follows:

$$dF = \frac{\partial F}{\partial t}dt + \frac{\partial F}{\partial x}dx + \frac{1}{2}\frac{\partial^2 F}{\partial x^2}(dx)^2 \tag{A.3}$$

# A.2 McDonald Siegel analysis for single stochastic processes

McDonald and Siegel (1986) considered the question of when it is optimal to invest a sunk cost $I$ in a project $V$ whose value varies according to the following stochastic process[1]:

$$dV = \alpha V dt + \sigma V dz \tag{A.4}$$

Note that this may also be formulated equivalently as:

$$d(\ln V) = \alpha dt + \sigma dz$$

Our goal is to maximize the difference between the value of the difference between $F(V_t)$ and $I$, where $t$ is the time at which the exercise is taken. In particular, we want to find the critical value $V^*$ which ensures that $F(V)$ will be the maximum. Because the time value of money means that the same dollar of return will be worth less in the future than it is today, we can turn this requirement into the following equation:

$$F(V) = \max \mathcal{E}\left[(V_T - I)e^{-rT}\right],$$

where $\mathcal{E}$ denotes expectation, $T$ is the time at which the investment is made, and $r$ is the discount rate.

[1]The actual problem considered allowed $I$ to vary stochastically as well, but for simplicity $I$ is considered to be constant in real terms

Now, since the only return an investor makes before the investment $I$ is made is capital appreciation, the expected value of $dF$ must equal this return:

$$rF(V)dt = \mathcal{E}(dF) \tag{A.5}$$

In this equation, $r$ represents the company's required real (i.e. inflation adjusted) rate of return. To solve it, we first we expand dF using Ito's lemma (equation A.3):

$$dF = \frac{\partial F}{\partial t}dt + \frac{\partial F}{\partial V}dV + \frac{1}{2}\frac{\partial^2 F}{\partial V^2}(dV)^2 \tag{A.6}$$

We can then simplify equation A.6 by noting that since $F(V)$ is not a function of $t$, $\frac{\partial F}{\partial t}dt = 0$. Thus, $dF$ can be written:

$$dF = \frac{\partial F}{\partial V}dV + \frac{1}{2}\frac{\partial^2 F}{\partial V^2}(dV)^2 \tag{A.7}$$

Next, we substitute equation A.4 for $dV$ into equation A.7, and compute the expected value

$$\begin{aligned} \mathcal{E}(dF) &= \mathcal{E}\{F'(V)\alpha V dt + F'(V)\sigma V dz \\ &+ \frac{1}{2}F''(V)\left[\alpha^2 V^2 dt^2 + 2\alpha\sigma V^2 dt dz + \sigma^2 V^2 dz^2\right]\} \end{aligned}$$

It is now possible to simplify this expression. $\mathcal{E}(F'(V)\sigma V dz) = 0$ and $\mathcal{E}(2\alpha\sigma V^2 dt dz) = 0$, since $\mathcal{E}(dz) = 0$. We can also eliminate the term $\alpha^2 V^2 dt^2$, since it goes to 0 (compare the original derivation of Ito's lemma).

Having eliminated these terms, we are now left with

$$\mathcal{E}(dF) = \mathcal{E}\{F'(V)\alpha V dt + \frac{1}{2}F''(V)\sigma^2 V^2 dz^2\}$$

Noting that $\mathcal{E}(dz^2) = dt$ and using equation A.5, we can write:

$$rF(V)dt = \alpha V F'(V)dt + \frac{1}{2}\sigma^2 V^2 F''(V)dt \tag{A.8}$$

Collecting terms we have:

$$\frac{1}{2}\sigma^2 V^2 F''(V) + \alpha V F'(V) - rF(V) = 0 \tag{A.9}$$

This differential equation can be solved by equations of the type:

$$F(V) = A_1 V^{\beta_1} + A_2 V^{\beta_2}, \tag{A.10}$$

where $\beta_1 > 0$ and $\beta_2 < 0$. In addition, F(V) must satisfy three boundary conditions:

$$F(0) = 0, \tag{A.11}$$

$$F(V^*) = V^* - I, \tag{A.12}$$

$$F'(V^*) = 1. \tag{A.13}$$

Note that although equation A.9 is second order, there are three boundary conditions. Equation A.11 can be derived by noting that if V in equation A.4 ever goes to 0, it will remain there. The second two boundary conditions include the variable $V^*$, which is the value of $V$ at which it is optimal to invest. Equation A.12 is known as the 'value matching' condition, and it merely states that the firm receives a payoff of $V^* - I$ when it invests. Equation A.13 is the 'smooth pasting' requirement. Its derivation is technical, but details may be found in Dixit and Pindyck (1994).

It is now possible to solve equation A.10 subject to the boundary conditions. Boundary condition A.11 requires that $A_2 = 0$. For the remainder of this analysis, we will therefore rename variable $\beta_1$ as $\beta$. By substituting the equation

$$F(V) = AV^{\beta} \tag{A.14}$$

in equations A.12 and A.13, we find that

$$V^* = \frac{\beta}{\beta - 1} I, \tag{A.15}$$

and that

$$A = \frac{(V^* - I)}{(V^*)^{\beta}} \tag{A.16}$$

Using the terminology of chapter 1 of the text, $C^* = \frac{\beta}{\beta - 1}$.

We can now solve for $\beta$. Substituting equation A.14 into equation A.9, we have

$$\frac{1}{2}\sigma^2 V^2 \beta(\beta - 1)AV^{\beta-2} + \alpha V \beta A V^{\beta-1} - rAV^{\beta} = 0$$

Dividing through by $AV^\beta$ and multiplying by 2, we can write

$$\sigma^2\beta(\beta-1)+2\alpha\beta-2r=0$$

Then

$$\beta^2\sigma^2+2(\alpha-\frac{\sigma^2}{2})\beta-2r=0$$

So the positive root of this equation is

$$\beta=\frac{1}{2}-\frac{\alpha}{\sigma^2}+\sqrt{\left[\frac{\alpha}{\sigma^2}-\frac{1}{2}\right]^2+\frac{2r}{\sigma^2}}>0 \tag{A.17}$$

Note that a firm would never want to invest if $\beta<0$, since the value of $F(V)$ would always decrease over time. Equations A.14, A.15 and A.16 provide the parameters required to specify the solutions for $V^*$ and $F(V)$.

## A.3 Single Poisson processes

We can extend the analysis of the previous section to include processes that have a component that varies continuously over time, but can also take a fixed jump with probability $\lambda$. We can define this Poisson process in a similar way to the Wiener process as follows:

$$dq=\begin{cases} 0 & \text{with probability } 1-\lambda dt, \\ u & \text{with probability } \lambda dt \end{cases} \tag{A.18}$$

Then we can write stochastic functions that include Poisson elements as follows:

$$dx=a(x,t)dt+b(x,t)dz+g(x,t)dq$$

In general, if $H = H(x,t)$, then $\mathcal{E}(dH)$ can be found by using Ito's lemma for combined Brownian and Poisson processes, i.e.:

$$\begin{aligned} \mathcal{E}(\mathrm{dH}) &= \tfrac{\partial H}{\partial t} + \left[a(x,t)\tfrac{\partial H}{\partial x} + \tfrac{1}{2}b^2(x,t)\tfrac{\partial^2 H}{\partial x^2}\right] dt \\ &+ \mathcal{E}_{\mathrm{u}}\{\lambda[\mathrm{H}(\mathrm{x}+\mathrm{g}(\mathrm{x},\mathrm{t})\mathrm{u},\mathrm{t}) - \mathrm{H}(\mathrm{x},\mathrm{t})]\}\mathrm{dt}, \end{aligned} \tag{A.19}$$

where the expectation is with respect to the size of the jump. In our specific case, we have:

$$dV = \alpha V dt + \sigma V dz + V dq$$

In other words, $a(x,t) = \alpha$ and $b(x,t) = \sigma$. In addition, since $F(V)$ is not a function of $t$, $\frac{\partial F}{\partial t} = 0$. Restating equation A.5 for the appreciation an investor makes before investing, we have:

$$rF(V)dt = \mathcal{E}(dF) \tag{A.20}$$

Then using the expanded Ito's lemma and the above equation, we have:

$$rF(V)dt = \alpha V F'(V)dt + \frac{1}{2}\sigma^2 V^2 F''(V)dt - \lambda\left\{F(V) - F[(1-\phi)V]\right\} dt$$

Here we have made an important limiting assumption that if a Poisson event occurs, the value of $V$ falls (or rises) by a fixed percentage $\phi$, where $0 \leq \phi \leq 1$. Then, collecting terms we have:

$$\frac{1}{2}\sigma^2 V^2 F''(V) + \alpha V F'(V) - (r+\lambda)F(V) + \lambda F[(1-\phi)V] = 0$$

We can again choose a solution of the form given in equation A.14. Substituting this form into the above equation we can write

$$\frac{1}{2}\sigma^2\beta(\beta-1) + \alpha\beta - (r+\lambda) + \lambda(1-\phi)^\beta = 0$$

A solution to this equation may be found numerically. One way to accomplish this is to use a seed value of 1 for $\beta$, and then to increase $\beta$ by $-1$ times the value of expression on the left hand of the above equation. This process may be repeated until the error falls below an arbitrarily small value. Once $\beta$ has been found, $V^*$ and $A$ can then be found as well by using equations A.15 and A.16. The model described in Section 6.3.3 relies upon this approximation technique.

## A.4 Multiple Poisson processes

We can extend the derivation for single Poisson processes to situations in which there are two Poisson processes. In this case, $dx$ is given as follows:

$$dx = a(x,t)dt + b(x,t)dz + g_1(x,t)dq_1 + g_2(x,t)dq_2 \tag{A.21}$$

Then in general for a function $H = H(x,t)$, we have:

$$\begin{aligned} \mathcal{E}(\mathrm{dH}) &= \tfrac{\partial H}{\partial t} + \left[a(x,t)\tfrac{\partial H}{\partial x} + \tfrac{1}{2}b^2(x,t)\tfrac{\partial^2 H}{\partial x^2}\right] dt \\ &+ \mathcal{E}_{\mathrm{u_1}}\{\lambda_1[\mathrm{H}(\mathrm{x}+\mathrm{g}_1(\mathrm{x},\mathrm{t})\mathrm{u}_1,\mathrm{t}) - \mathrm{H}(\mathrm{x},\mathrm{t})]\}\mathrm{dt} \\ &+ \mathcal{E}_{\mathrm{u_2}}\{\lambda_2[\mathrm{H}(\mathrm{x}+\mathrm{g}_2(\mathrm{x},\mathrm{t})\mathrm{u}_2,\mathrm{t}) - \mathrm{H}(\mathrm{x},\mathrm{t})]\}\mathrm{dt}, \end{aligned} \tag{A.22}$$

where the expectation in both cases is with respect to the size of the jump. In general, if $x$ is a function of $i$ Poisson processes, we have:

$$\begin{aligned} \mathcal{E}(\mathrm{dH}) &= \tfrac{\partial H}{\partial t} + \left[a(x,t)\tfrac{\partial H}{\partial x} + \tfrac{1}{2}b^2(x,t)\tfrac{\partial^2 H}{\partial x^2}\right] dt \\ &+ \textstyle\sum_i \mathcal{E}_{\mathrm{u_i}}\{\lambda_i[\mathrm{H}(\mathrm{x}+\mathrm{g}_i(\mathrm{x},\mathrm{t})\mathrm{u}_i,\mathrm{t}) - \mathrm{H}(\mathrm{x},\mathrm{t})]\}\mathrm{dt} \end{aligned} \tag{A.23}$$

Making the same limiting assumption as before, we can write:

$$dV = \alpha V dt + \sigma V dz + V dq_1 + V dq_2$$

Using equation A.5, we can write:

$$\begin{aligned} rF(V) &= \alpha V F'(V) + \tfrac{1}{2}\sigma^2 V^2 F''(V) \\ &- \lambda_1 F(V) + \lambda_1 F[(1-\phi_1)V] \\ &- \lambda_2 F(V) + \lambda_2 F[(1-\phi_2)V] \end{aligned}$$

Assuming $F(V) = AV^{\beta}$ as before, we have:

$$\frac{1}{2}\sigma^2\beta(\beta-1) + \alpha\beta - (r + \lambda_1 + \lambda_2) + \lambda_1(1-\phi_1)^{\beta} + \lambda_2(1-\phi_2)^{\beta} = 0$$

The generalized equation for multiple stochastic variables with several Poisson processes is therefore as follows:

$$\frac{1}{2}\sigma^2\beta(\beta-1) + \alpha\beta - (r + \sum_i \lambda_i) + \sum_i \lambda_i(1-\phi_i)^{\beta} = 0. \qquad \text{(A.24)}$$

The same simple iterative numerical solution technique may be used as in the previous section to find the positive root of $\beta$.

## A.5 Normalized random numbers

The random number generator in the Lotus 123 Spreadsheet programme produces a uniform distribution of numbers between 0 and 1. Unfortunately, the Wiener processes described in section A.1 rely upon random numbers with a normal distribution and with a mean of 0 and a $\sigma$ of 1. We can produce random numbers with a normal distribution for use in the computer model using the following methodology:

1. Let $D_1$ and $D_2$ be uniformly distributed in the interval $-1$ to 1, and also be independently distributed. These numbers are readily available from the Lotus programme.

2. Let $E$ be defined as $E = D_1^2 + D_2^2$.

3. Then if $0 \leq E \leq 1$, let $F$ be defined as follows:

$$F = \sqrt{-2\frac{\ln E}{E}}$$

4. Then if $G_1 = D_1 \times F$ and $G_1 = D_1 \times F$, $G_1$ and $G_2$ will be normally distributed with mean 0 and $\sigma = 1$. Page C-8 shows the calculations made in the model to ensure that the random numbers generated meet the required characteristics.

# Appendix B

# Industry interviews

The locations and approximate dates of the interviews used to develop the five cases are as follows (slightly disguised to preserve confidentiality):

- **Global pharmaceutical company.** London, June-September, 1992
- **Light manufacturing company.** New York State, January-May, 1991
- **Global consumer goods company.** Paris and Amsterdam, January - March, 1993
- **Global insurance brokerage.** Atlanta, Georgia, August-December, 1994
- **Global fragrance company.** Paris and New York, March-April, 1995

# Appendix C

# Sample Output From Investment Model

The following pages contain a printout of the investment model described in detail in Chapter 5.

CASHFLOW SIMULATION		Fit period select		1 10 Years

| | | | |
|---|---|---|---|
| WACC | 7.0% | Tax rate | 33.25% |
| Inflation | 0.0% | Investment cost | 60 |

| | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sales | 100.0000 | 102.5608 | 100.2756 | 101.6785 | 105.3196 | 103.6675 | 107.4335 | 106.2788 | 104.0657 | 101.1964 | 102.0853 |
| Labor | 35.0000 | 35.4196 | 38.1432 | 40.1870 | 37.9329 | 38.3198 | 38.8964 | 42.6975 | 42.8546 | 45.2078 | 48.5424 |
| Fixed costs | 55.0000 | 56.8375 | 61.0353 | 54.9740 | 52.8830 | 51.5049 | 42.3800 | 43.7925 | 43.2857 | 42.3266 | 35.4488 |
| Pretax profit | 10.0000 | 10.3037 | 1.0971 | 6.7175 | 14.5037 | 13.8428 | 26.1571 | 19.7888 | 17.9254 | 13.6620 | 18.0941 |
| Tax | (3.3250) | (3.4260) | (0.3648) | (2.2336) | (4.8225) | (4.6027) | (8.6972) | (6.5798) | (5.9602) | (4.5426) | (6.0163) |
| Change in working capital | | | | | | | | | | | |
| Depreciation tax shield | | | | | | | | | | | |
| Cash | 6.6750 | 6.8777 | 0.7323 | 4.4839 | 9.6812 | 9.2401 | 17.4598 | 13.2090 | 11.9652 | 9.1194 | 12.0778 |
| Terminal value for year | | | | | | | | | | | |
| Actual value | | | | | | | | | | | |
| Value (t) | 145.5439 | 127.0502 | 147.3675 | 147.8236 | 135.1740 | 119.3811 | 85.0767 | 94.8852 | 75.9374 | 47.6416 | 41.8571 |
| Time | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Random number set #1 | | 0.5122 | -0.4456 | 0.3197 | 0.6755 | -0.3137 | 0.7265 | -0.2150 | -0.4165 | -0.5514 | 0.1757 |
| Random number set #2 | | -0.1918 | 1.1893 | 0.6933 | -1.6402 | -0.2298 | -0.1267 | 1.6324 | -0.3685 | 0.7216 | 1.1226 |
| Random number set #3 | | 1.2353 | 1.9448 | -1.0931 | -0.0182 | 0.1919 | -2.4590 | 1.2338 | 0.4461 | 0.2604 | -2.2016 |
| Random number set #4 | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Random number set #5 | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | | |
|---|---|---|---|
| Random number offest | 40 | Number of variables | 3 |

| | Sigma for 10 Years | Alpha for 10 Years |
|---|---|---|
| Variable #1 | 0.050 | 0.000 |
| Variable #2 | 0.047 | 0.021 |
| Variable #3 | 0.057 | -0.037 |
| Variable #4 | 0.000 | 0.000 |
| Variable #5 | 0.000 | 0.000 |

Toggle on sigma		1 Normal

GOVERNMENT COST CALCUATLION

Case number 1 Give or take subsidy 50.0

BASE CASE
Simulated figures

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
| Sales | 100.0 | 102.6 | 100.3 | 101.9 | 105.3 | 103.7 | 107.4 | 106.3 | 104.1 | 101.2 | 102.1 |
| Labor | 35.0 | 35.4 | 38.1 | 40.2 | 37.9 | 38.3 | 38.9 | 42.7 | 42.9 | 45.2 | 48.5 |
| Fixed costs | 55.0 | 56.8 | 61.0 | 55.0 | 52.9 | 51.5 | 42.4 | 43.8 | 43.3 | 42.3 | 35.4 |



CASE 1
Government commitment levels (Sigma_labor, sigma_parts = 0) Subsidy = 50.0

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
| Sales | 100.0 | 102.6 | 100.3 | 101.9 | 105.3 | 103.7 | 107.4 | 106.3 | 104.1 | 101.2 | 102.1 |
| Labor | 35.0 | 35.7 | 36.5 | 37.3 | 38.0 | 38.8 | 39.6 | 40.5 | 41.3 | 42.2 | 43.1 |
| Fixed costs | 55.0 | 53.0 | 51.0 | 49.1 | 47.3 | 45.6 | 43.9 | 42.2 | 40.7 | 39.2 | 37.7 |

MODEL INPUTS

| Variable | Value | Description |
| --- | --- | --- |
| SIMUL (Entered) | 100 | Number of simulation runs (equivalent to M) |
| P (Entered) | 160 | Number of rows in random variable output (up to 160) |
| Q (Calculated) | 120 | Number of columns in random variable output (Maximum value = 120) |

VALUATION OUTPUTS

Invest in year 0 65.0%
Invest before year 10 77.0%

RAW VALUATION OUTPUT

| Alpha | Avg alpha = | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0199 | 0.004065 | 1 + | 386.207 | 374.601 | 424.878 | 465.945 | 453.351 | 428.858 | 470.304 | 475.151 |
| 0.0391 | | 2 + | 155.829 | 167.867 | 182.363 | 160.486 | 138.062 | 184.957 | 215.125 | 238.721 |
| 0.0655 | | 3 + | 487.879 | 541.555 | 612.777 | 691.198 | 783.158 | 831.385 | 816.842 | 858.647 |
| 0.0240 | | 4 + | 58.062 | 42.355 | 99.497 | 79.395 | 103.430 | 89.998 | 102.979 | 59.578 |
| 0.0263 | | 5 + | 272.842 | 291.721 | 266.605 | 275.552 | 269.232 | 290.015 | 295.405 | 318.622 |
| 0.0162 | | 6 + | 56.488 | 71.680 | 54.891 | 51.580 | 66.089 | 57.691 | 47.178 | 98.655 |
| 0.0774 | | 7 + | 60.131 | 78.893 | 83.873 | 97.716 | 55.730 | 68.610 | 71.913 | 39.524 |
| 0.0456 | | 8 + | 212.968 | 237.594 | 252.016 | 246.200 | 321.057 | 362.750 | 352.148 | 375.647 |
| 0.0492 | | 9 + | 267.729 | 272.220 | 310.295 | 302.530 | 307.681 | 359.080 | 386.606 | 458.231 |
| 0.0383 | | 10 + | 408.164 | 388.448 | 417.109 | 473.494 | 526.590 | 525.001 | 611.392 | 663.968 |
| 0.0416 | | 11 + | 364.611 | 334.084 | 333.701 | 370.953 | 424.412 | 445.197 | 477.342 | 498.274 |
| 955 | | 12 + | 245.759 | 259.236 | 301.033 | 298.995 | 286.863 | 229.229 | 199.028 | 139.015 |
| 143 | | 13 + | 47.054 | 15.000 | 15.000 | 15.000 | 15.000 | 15.000 | 15.000 | 15.000 |
| 387 | | 14 + | 199.052 | 223.496 | 198.448 | 180.198 | 164.330 | 182.622 | 230.082 | 272.136 |
| 0.0324 | | 15 + | 164.287 | 201.312 | 210.975 | 181.502 | 168.329 | 179.602 | 175.681 | 183.418 |
| -0.1029 | | 16 + | 41.961 | 69.262 | 62.117 | 36.232 | 23.037 | 32.229 | 26.288 | 15.000 |
| 0.0727 | | 17 + | 65.051 | 44.331 | 19.706 | 31.330 | 36.233 | 75.305 | 65.969 | 120.565 |
| -0.1510 | | 18 + | 67.874 | 39.919 | 15.000 | 15.000 | 15.000 | 15.000 | 15.000 | 15.000 |
| 0.0778 | | 19 + | 115.752 | 141.674 | 129.889 | 125.658 | 162.738 | 201.036 | 201.845 | 212.508 |
| -0.0016 | | 20 + | 92.779 | 108.025 | 97.287 | 34.677 | 16.467 | 22.228 | 31.242 | 46.924 |
| -0.1716 | | 21 + | 245.996 | 236.513 | 227.174 | 184.255 | 191.485 | 175.973 | 138.672 | 113.955 |
| -0.0399 | | 22 + | 184.634 | 197.173 | 164.242 | 169.135 | 153.964 | 134.361 | 112.057 | 104.904 |
| -0.1234 | | 23 + | 51.504 | 15.000 | 15.000 | 15.000 | 15.000 | 15.000 | 15.000 | 15.000 |
| 0.0842 | | 24 + | 97.496 | 87.721 | 92.406 | 100.854 | 127.556 | 153.517 | 178.816 | 200.853 |
| -0.0767 | | 25 + | 171.242 | 187.129 | 165.221 | 138.024 | 130.023 | 115.620 | 99.590 | 59.589 |
| -0.2075 | | 26 + | 119.484 | 72.387 | 61.791 | 92.909 | 71.575 | 57.555 | 68.236 | 45.242 |
| 0.0636 | | 27 + | 247.569 | 257.741 | 325.166 | 334.550 | 302.412 | 303.119 | 322.250 | 389.378 |
| -0.1248 | | 28 + | 52.267 | 36.457 | 26.053 | 15.000 | 15.000 | 15.000 | 15.000 | 15.000 |
| -0.0724 | | 29 + | 73.964 | 75.240 | 69.885 | 48.764 | 49.380 | 57.283 | 41.734 | 29.251 |
| 0.0709 | | 30 + | 286.853 | 306.645 | 331.771 | 380.679 | 424.723 | 451.666 | 488.208 | 498.086 |
| 0.0429 | | 31 + | 159.112 | 177.499 | 171.031 | 190.503 | 206.793 | 195.119 | 216.494 | 246.154 |
| 0.0300 | | 32 + | 267.786 | 304.145 | 278.358 | 311.855 | 308.413 | 298.040 | 313.039 | 356.085 |

ALPHA AND SIGMA CALCULATION

| Alpha used | Avg sigma^2 | Avg sigma |
|---|---|---|
| 0.004065 | 0.073715 | 0.271505 |

| Alpha used for row | Computed Sigma ^2 | LN OF PAIRS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.004065 | 0.004103 | 1 + | 0.001196 | 0.014854 | 0.007779 | 0.000990 | 0.003553 | 0.007777 | 0.000038 | 0.000647 |
| 0.004065 | 0.026343 | 2 + | 0.004948 | 0.006204 | 0.017386 | 0.023893 | 0.083149 | 0.021618 | 0.010003 | 0.026920 |
| 0.004065 | 0.006835 | 3 + | 0.010062 | 0.014278 | 0.013539 | 0.014603 | 0.003102 | 0.000471 | 0.002102 | 0.001444 |
| 0.004065 | 0.150098 | 4 + | 0.102071 | 0.722460 | 0.052792 | 0.067806 | 0.020499 | 0.017077 | 0.303950 | 0.001916 |
| 0.004065 | 0.002882 | 5 + | 0.003949 | 0.008854 | 0.000838 | 0.001970 | 0.000002 | 0.000206 | 0.005125 | 0.002721 |
| 0.004065 | 0.125296 | 6 + | 0.054810 | 0.073404 | 0.004391 | 0.059433 | 0.019590 | 0.042118 | 0.538206 | 0.023893 |
| 0.004065 | 0.174940 | 7 + | 0.071552 | 0.003266 | 0.022111 | 0.319926 | 0.041556 | 0.001845 | 0.363149 | 0.559421 |
| 0.004065 | 0.017685 | 8 + | 0.011100 | 0.003010 | 0.000751 | 0.068335 | 0.013931 | 0.001138 | 0.003664 | 0.047500 |
| 0.004065 | 0.008515 | 9 + | 0.000158 | 0.016090 | 0.000865 | 0.000164 | 0.022626 | 0.004871 | 0.027523 | 0.000120 |
| 0.004065 | 0.007761 | 10 + | 0.002870 | 0.004505 | 0.015062 | 0.010448 | 0.000050 | 0.021985 | 0.006151 | 0.000408 |
| 0.004065 | 0.005343 | 11 + | 0.008373 | 0.000027 | 0.010356 | 0.017047 | 0.001914 | 0.004310 | 0.001509 | 0.002240 |
| 0.004065 | 0.040353 | 12 + | 0.002433 | 0.021146 | 0.000118 | 0.002069 | 0.052143 | 0.021124 | 0.131716 | 0.131506 |
| 0.004065 | 0.146272 | 13 + | 1.316319 | 0.000017 | 0.000017 | 0.000017 | 0.000017 | 0.000017 | 0.000017 | 0.000017 |
| 0.004065 | 0.015537 | 14 + | 0.012492 | 0.015112 | 0.010107 | 0.009263 | 0.010297 | 0.051507 | 0.026831 | 0.000002 |
| 0.004065 | 0.010978 | 15 + | 0.039671 | 0.001833 | 0.023883 | 0.006306 | 0.003692 | 0.000683 | 0.001523 | 0.012313 |
| 0.004065 | 0.137360 | 16 + | 0.247099 | 0.012755 | 0.295000 | 0.208764 | 0.110021 | 0.043182 | 0.319390 | 0.000017 |
| 0.004065 | 0.219569 | 17 + | 0.150201 | 0.663927 | 0.211221 | 0.019971 | 0.529280 | 0.018614 | 0.358730 | 0.022044 |
| 0.004065 | 0.139138 | 18 + | 0.286074 | 0.966049 | 0.000017 | 0.000017 | 0.000017 | 0.000017 | 0.000017 | 0.000017 |
| 0.004065 | 0.020809 | 19 + | 0.039209 | 0.008265 | 0.001382 | 0.064775 | 0.042965 | 0.000000 | 0.002248 | 0.028398 |
| 0.004065 | 0.418254 | 20 + | 0.021926 | 0.011829 | 1.072581 | 0.560665 | 0.087558 | 0.113133 | 0.162181 | 0.294106 |
| 0.004065 | 0.107193 | 21 + | 0.001881 | 0.001967 | 0.045566 | 0.001185 | 0.007840 | 0.058701 | 0.040150 | 0.003334 |
| 0.004065 | 0.025534 | 22 + | 0.003800 | 0.034896 | 0.000640 | 0.009613 | 0.019671 | 0.034441 | 0.004904 | 0.023996 |
| 0.004065 | 0.170217 | 23 + | 1.531822 | 0.000017 | 0.000017 | 0.000017 | 0.000017 | 0.000017 | 0.000017 | 0.000017 |
| 0.004065 | 0.019367 | 24 + | 0.012035 | 0.002300 | 0.006958 | 0.053276 | 0.032830 | 0.022048 | 0.012577 | 0.003419 |
| 0.004065 | 0.051804 | 25 + | 0.007167 | 0.016533 | 0.033827 | 0.004068 | 0.014755 | 0.023505 | 0.267968 | 0.097426 |
| 0.004065 | 0.210990 | 26 + | 0.255246 | 0.026355 | 0.163055 | 0.070192 | 0.049315 | 0.027609 | 0.172228 | 0.002290 |
| 0.004065 | 0.013227 | 27 + | 0.001310 | 0.052127 | 0.000595 | 0.011038 | 0.000003 | 0.003265 | 0.034283 | 0.003980 |
| 0.004065 | 0.061973 | 28 + | 0.132718 | 0.115646 | 0.309298 | 0.000017 | 0.000017 | 0.000017 | 0.000017 | 0.000017 |
| 0.004065 | 0.060530 | 29 + | 0.000170 | 0.006068 | 0.132446 | 0.000072 | 0.020850 | 0.102884 | 0.129222 | 0.025841 |
| 0.004065 | 0.006911 | 30 + | 0.003926 | 0.005578 | 0.017808 | 0.011113 | 0.003299 | 0.005436 | 0.000255 | 0.000970 |
| 0.004065 | 0.007917 | 31 + | 0.011087 | 0.001696 | 0.010765 | 0.006082 | 0.003866 | 0.009978 | 0.015457 | 0.004961 |
| 0.004065 | 0.006514 | 32 + | 0.015191 | 0.008586 | 0.012005 | 0.000230 | 0.001465 | 0.002028 | 0.015569 | 0.001499 |

## OUTPUT VALUES - MAIN PARAMETERS

| | | |
|---|---|---|
| Fit method | 0 | Overall average alpha |
| Alpha | 0.004065 | |
| Sigma | 0.27150 | |
| V* | 2.120 | |
| Beta_1 | 1.892991 | |
| R | 0.07 | |
| Delta | 0.0659 | |
| Threshold value | 127.1899 | |

Average C* 2.12

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Threshold value | 127.2 | 127.2 | 127.2 | 127.2 | 127.2 | 127.2 | 127.2 | 127.2 | 127.2 | 127.2 | 127.2 |
| Random number value | | 0.51215 | -0.44562 | 0.31971 | 0.675524 | -0.31374 | 0.72655 | -0.21496 | -0.41646 | -0.55144 | 0.175668 |
| Simulation of reality | 101.2 | 115.7 | 101.7 | 110.6 | 130.8 | 119.7 | 143.3 | 134.9 | 119.7 | 101.8 | 106.6 |
| Initial govt investment | 28.0 | | | | | | | | | | |
| Investment time | 3.82049 | | | | | | | | | | |
| Base year select | 3 | | | | | | | | | | |
| Subsidy cost | -6.1 | | | | | | | | | | |

SUBSIDY COST -6.1

| Trial | Row in Raw Output | Outcome | Labor Subsidy (Sigma = 0) |
|---|---|---|---|
| 1 | | | -97.3 |
| 2 | | | -105.4 |
| 3 | | | -6.0 |
| 4 | | | -1.1 |
| 5 | | | -97.1 |
| 6 | | | -27.4 |
| 7 | | | 23.9 |
| 8 | | | -40.6 |
| 9 | | | -12.1 |
| 10 | | | -36.8 |
| 11 | | | 2.2 |
| 12 | | | -76.6 |
| 13 | | | 20.3 |
| 14 | | | 134.9 |
| 15 | | | |
| 16 | | | -28.2 |
| 17 | | | |
| 18 | | | 35.3 |
| 19 | | | 49.2 |
| 20 | | | |
| 21 | | | -22.0 |
| 22 | | | 9.0 |
| 23 | | | 88.1 |
| 24 | | | -66.3 |
| 25 | | | -14.5 |
| 26 | | | -90.1 |
| 27 | | | |
| 28 | | | -66.0 |
| 29 | | | 96.0 |
| 30 | | | -42.4 |
| 31 | | | 77.1 |
| 32 | | | -23.3 |
| 33 | | | -2.8 |
| 34 | | | -18.3 |

RANDOM NUMBER GENERATOR Average= 0.000098 Std = 0.999942

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 + | -0.186392 | 0.181682 | 1.456098 | -1.373589 | 1.192038 | 0.310421 | 0.642379 | 0.903281 | 1.006980 | 0.840782 |
| 2 + | 0.234051 | -0.503823 | -0.924458 | 0.304039 | -1.972715 | 1.629491 | -1.658376 | -0.211142 | 0.251692 | -0.383273 |
| 3 + | 0.351153 | 0.751705 | 0.155923 | 2.477422 | 1.156985 | 1.488792 | 1.416799 | -0.982680 | 0.585198 | -0.468767 |
| 4 + | -0.621118 | -1.453916 | 1.245840 | 0.904749 | -0.027352 | -0.354962 | -1.029541 | -0.453620 | -1.764319 | 0.439671 |
| 5 + | 0.490245 | -0.640555 | 0.944189 | -0.652441 | 0.234202 | 1.115207 | 0.779350 | 0.593986 | -0.524315 | -0.995319 |
| 6 + | -1.596929 | -0.253606 | 0.827158 | 0.089568 | -0.296848 | -1.180303 | 0.617909 | -0.031069 | -2.610350 | 1.234298 |
| 7 + | 0.112916 | -1.837854 | 0.773004 | 0.185958 | 0.116311 | -0.247867 | -1.345257 | 0.091220 | -0.164028 | -0.589229 |
| 8 + | -0.799418 | 1.240543 | -0.395045 | 1.693976 | 0.247704 | -0.791426 | -0.185563 | 1.287141 | -0.732657 | -0.839926 |
| 9 + | 0.115906 | 1.020627 | -0.412571 | -1.061808 | 0.533912 | 1.208067 | 1.155401 | -1.744592 | 1.586450 | -0.039898 |
| 10 + | 0.662175 | -0.001044 | 2.215530 | -0.669573 | -0.097954 | 0.673327 | 1.142160 | 1.883092 | -0.261851 | 1.323526 |
| 11 + | -0.668449 | 0.389486 | 0.636576 | 0.352487 | 2.010823 | 1.333415 | 0.007925 | 0.193032 | 0.575805 | -0.142671 |
| 12 + | -0.015609 | 0.079749 | 0.595522 | -0.262535 | -1.576982 | -0.158646 | 0.808981 | 1.491696 | 0.068430 | 0.736170 |
| 13 + | 0.590908 | -2.477874 | -0.075368 | -0.987572 | 1.655846 | 0.578704 | 0.611508 | -2.279603 | -0.940488 | 0.574889 |
| 14 + | 0.571992 | -0.677333 | -0.200935 | 0.881434 | 0.749007 | 1.209585 | -0.766156 | -0.254720 | 1.769581 | -0.472356 |
| 15 + | -1.356824 | 1.041504 | 0.867543 | -0.392677 | -1.221789 | -0.216429 | -0.623531 | -1.432374 | -0.354622 | 1.471250 |
| 16 + | -0.329507 | -1.576221 | 1.207670 | -0.090054 | -0.140986 | -0.660768 | -0.415553 | 1.096185 | -0.024247 | 2.543190 |
| 17 + | -0.246847 | 0.356140 | -1.498212 | -2.186615 | 1.244518 | -1.524609 | 0.169110 | 2.399246 | -1.369779 | -0.547087 |
| 18 + | 0.170268 | -0.399434 | 0.255623 | 0.089512 | -0.351930 | 0.861682 | -0.703598 | -0.490192 | -0.753007 | -1.602936 |
| 19 + | 0.663981 | -1.252114 | -1.029976 | -1.054111 | -1.992956 | 0.552276 | 0.511675 | 0.377776 | 1.287992 | 0.520182 |
| 20 + | -0.426727 | 0.623737 | -1.189768 | -1.129707 | -1.401087 | -0.842742 | -0.701639 | -1.057986 | 0.692648 | 1.331857 |
| 21 + | -0.944784 | 0.404667 | -0.739096 | -0.676438 | -0.576777 | -0.395616 | -0.870827 | -1.269581 | 0.604097 | 0.596216 |
| 22 + | 1.533729 | -1.530753 | -1.290624 | -0.208619 | -1.012352 | 2.473244 | 0.864565 | -0.129162 | -0.656544 | -0.273206 |
| 23 + | 0.796324 | 1.731466 | 0.419320 | -0.623101 | 0.124497 | 0.333734 | -1.291114 | -0.042464 | -0.041334 | -1.446044 |
| 24 + | -0.581183 | -0.207783 | -0.654501 | 2.239063 | 0.328777 | -0.397456 | 0.347509 | 0.080177 | 0.162305 | -0.737354 |
| 25 + | 0.162422 | -0.38976 | 0.347986 | -0.55936 | 0.34838 | -0.54765 | 0.9652 | -0.31256 | 0.583923 | -0.03356 |
| 26 + | -1.48301 | -0.18368 | -0.63633 | -2.23216 | 0.050449 | -0.04716 | 0.776979 | -0.96598 | -1.60813 | 0.52921 |
| 27 + | -0.30755 | -0.416 | -1.50368 | -2.90315 | -0.29147 | -0.19761 | -0.15379 | 0.607457 | -0.98483 | -1.06825 |
| 28 + | -1.84119 | -1.71217 | -1.2877 | 0.579175 | 0.246497 | 0.93233 | -0.50772 | -1.83985 | 0.535087 | -0.06881 |
| 29 + | 1.644076 | 0.701088 | 1.102808 | 1.218595 | -1.51071 | -0.0814 | -0.49546 | -1.2314 | 0.162554 | 0.408795 |
| 30 + | 1.600934 | -1.15527 | 0.787674 | -1.88466 | -0.04598 | -0.33439 | -0.59799 | -0.30684 | 0.625268 | -0.85737 |
| 31 + | 0.200193 | -0.91536 | 0.31485 | -0.20929 | 1.544823 | -0.1202 | 0.763755 | 0.556625 | 0.304929 | 2.503709 |
| 32 + | -1.38439 | -0.37711 | -0.0834 | -0.45431 | -0.38875 | 1.378 | -0.68139 | 0.081077 | -0.94266 | -0.39994 |
| 33 + | -1.81649 | 0.383081 | 0.689336 | -0.62928 | 0.437715 | -0.9619 | -0.56171 | -0.19138 | 1.254712 | -0.90207 |
| 34 + | 0.367649 | 0.399737 | -0.64499 | -0.09383 | 2.312884 | 0.987523 | -1.58271 | 1.534195 | -0.00683 | -1.14063 |
| 35 + | 0.368492 | -1.56392 | 0.114482 | 0.169352 | -1.07518 | -0.27809 | 0.101748 | 0.932616 | -0.05667 | 0.912646 |
| 36 + | 0.768907 | 1.128337 | 1.298029 | 0.692766 | 1.100124 | -2.93951 | 0.082155 | -1.20197 | -1.26639 | 0.200486 |
| 37 + | -1.02212 | 0.028663 | 0.975962 | -1.18134 | 0.054461 | -1.34322 | -1.19692 | 0.714605 | 0.425287 | 0.921396 |

MACRO CODE

```
MAIN CODE       COMMANDS                                            COMMENTS

                {blank RUN_OUTPUT}
                {let CVAR1;0}
COUNTER1        {let CVAR1;CVAR1+1}
                {let CVAR2;0}
                {if CVAR1>P}{branch END_LOOP}
COUNTER2        {let CVAR2;CVAR2+2}
                {if CVAR2>Q}{branch COUNTER1}
                {RANDOM}
                {put RUN_OUTPUT;CVAR2-2;CVAR1-1;OUTPUT1}           Fill random number output
                {put RUN_OUTPUT;CVAR2-1;CVAR1-1;OUTPUT2}
                {branch COUNTER2}
END_LOOP        {calc}
                {blank RAW_OUTPUT}
                {blank SUB1_OUT}
                {let RANDOM_REF;0}                                  Random ref is the counter for which row of random numbers is used
                {let ROW_REF;0}{calc}                               Row ref is the counter for the raw output matrix
COUNTER3        {if ROW_REF>=SIMUL}{branch END_LOOP2}
                {calc}
                {if RANDOM_REF>=P}{let M:B34;"Warning - random number pool exceeded"}{branch END_LOOP2}
                {if VALUE_0<=.0005}{let RANDOM_REF;RANDOM_REF+1}{calc 5}{branch COUNTER3}
                {put RAW_OUTPUT;0;ROW_REF;A:B25}
                {put RAW_OUTPUT;1;ROW_REF;A:C25}
                {put RAW_OUTPUT;2;ROW_REF;A:D25}
                {put RAW_OUTPUT;3;ROW_REF;A:E25}
                {put RAW_OUTPUT;4;ROW_REF;A:F25}
                {if TOGGLE=2}{branch OUTPUT_SKIP}
                {put RAW_OUTPUT;5;ROW_REF;A:G25}
                {put RAW_OUTPUT;6;ROW_REF;A:H25}
                {put RAW_OUTPUT;7;ROW_REF;A:I25}
                {put RAW_OUTPUT;8;ROW_REF;A:J25}
                {put RAW_OUTPUT;9;ROW_REF;A:K25}
                {put SUB1_OUT;0;RANDOM_REF;+SUBSIDY}
                {if TOGGLE=1}{branch OUTPUT_SKIP}                   Controls length of output stored
                {put RAW_OUTPUT;10;ROW_REF;A:L25}
                {put RAW_OUTPUT;11;ROW_REF;A:M25}
                {put RAW_OUTPUT;12;ROW_REF;A:N25}
                {put RAW_OUTPUT;13;ROW_REF;A:O25}
                {put RAW_OUTPUT;14;ROW_REF;A:P25}
                {put RAW_OUTPUT;15;ROW_REF;A:Q25}
                {put RAW_OUTPUT;16;ROW_REF;A:R25}
                {put RAW_OUTPUT;17;ROW_REF;A:S25}
                {put RAW_OUTPUT;18;ROW_REF;A:T25}
                {put RAW_OUTPUT;19;ROW_REF;A:U25}

OUTPUT_SKIP     {let ROW_REF;ROW_REF+1}
                {let RANDOM_REF;RANDOM_REF+1}
                {calc 10}
                {branch COUNTER3}
END_LOOP2       {calc}

                {let ROW_REF;0}
                {calc}

SUBROUTINES

RANDOM                                                              Randon number generator
RETRY           {blank SEED1}{blank SEED2}
                {blank F}{blank R}
                {let SEED1;@rand*2-1}
                {let SEED2;@rand*2-1}
                {let R;SEED1^2+SEED2^2}
                {if R>=1}{RETRY}
                {let F;@Sqrt(-2*@ln(R)/R)}
                {let OUTPUT1;SEED1*F}
                {let OUTPUT2;SEED2*F}
                {return}
```

SECONDARY MACROS

```
Import_m    {goto}L:C4~
            /fcceRAND1.WK4~
            {esc}

Export_m    /fxvRAND1.WK4~ {esc}RUN_OUTPUT~
```

VARIABLES

| Name | Value | Description |
| --- | --- | --- |
| SEED1 | 0.428904 | |
| SEED2 | 0.595968 | |
| R | 0.539137 | |
| F | 1.513855 | |
| P | 160 | Row width of output matrix |
| Q | 120 | Column width of output matrix |
| OUTPUT1 | 0.649299 | |
| OUTPUT2 | 0.902210 | |
| CVAR1 | 161 | First counter variable |
| CVAR2 | 0 | Second counter variable |
| ROW_REF | 100 | Controls which row of raw output is filled |
| RANDOM_REF | 109 | Controls which row of random numbers is used |

# Bibliography


[1] Aizenman, Joshua and Marion, Nancy (1991). *Policy Uncertainty, Persistence and Growth.* NBER Working Paper No. 3848

[2] Bachtler, John and Michie, Rona (1993). *The Restructuring of Regional Policy in the European Community.* Regional Studies, Vol. 27.8, pp. 719-725

[3] Bachtler, John (1990). *Grants for Inward Investors. Giving Away Money?* National Westminster Bank Quarterly Review, May 1990, pp. 15-24

[4] Banham, John (1994). *The Anatomy of Change: Blueprint for a New Era.* Weidenfeld & Nicolson, London

[5] Bartmess, Andrew (1994). *The Plant Location Puzzle.* Harvard Business Review, March-April 1994, pp. 20-37

[6] Bartmess, Andrew and Cerny, Keith (1993). *Building Competitive Advantage through a Network of Capabilities.* California Management Review, Volume 35, No. 2, pp. 78-103

[7] Baumol, William and Blinder, A. (1985). *Economics - Principles and Policy.* Harcourt Brace Jovanovich, 3rd Edition

[8] Biehl, D. (1986). *The Contribution of Infrastructure to Regional Development.* EEC Report, Luxembourg, 1986

[9] Brealey, Richard and Myers, Stewart (1991). *Principles of Corporate Finance.* McGraw Hill, New York

[10] Brech, Michael and Sharp, Margaret (1984). *Inward Investment: Policy Options for the United Kingdom.* Chatham House Papers, Royal Institute of International Affairs, Routledge & Kegan Paul

[11] Cassell, M. (1993). *Business Locations in Europe.* Financial Times Survey, October 11, 1993, Edited by M. Cassell

[12] Cerny, Keith and Bartmess, Andrew (1992). *Kodak Business Imaging Systems Division.* Harvard Business School Case N9-693-043 and Model Note N9-693-044. Reprinted in M. Therese Flaherty (1996), "Global Operations Management", McGraw Hill, New York

[13] Chisholm, Michael (1990). *Regions in Recession and Resurgence.* Unwin Hyman, London

[14] Collis, Clive and Noon, David (1994). *Foreign Direct Investment in the UK Regions: Recent Trends and Policy Issues.* Regional Studies, Vol. 28.8, pp. 843-848

[15] Conway, Patrick (1988). *The Impact of Uncertainty on Private Investment in Turkey.* Department of Economics, University of North Carolina, Chapel Hill, NC, December 1988

[16] Coopers & Lybrand (1992). *Made in the U.K. - the Survey of British Manufacturers.* Coopers & Lybrand, Uxbridge and London

[17] Cowling, Keith and Sugden, Roger (1993). *Industrial Strategy: A Missing Link in British Economic Policy?* Oxford Review of Economic Policy, Vol. 9, No. 3, pp. 91-98

[18] *CSO Economic Trends (1995 Edition)*

[19] David, Rhys (1992). *A Thousand Projects Won in the Last Decade.* Financial Times Survey, September 16, 1992

[20] Dickin, Peter and Tickell, Adam (1992). *Competitors or Collaborators? The Structure of Inward Investment Promotion in Northern England.* Regional Studies, Vol. 26.1, pp. 99-106 (Policy review section, J. Mawson, ed.)

[21] Dixit, Avinash and Pindyck, Robert (1994). *Decision Making Under Uncertainty.* Princeton University Press, Princeton, N.J.

[22] Dixit, Avinash (1992). *Investment and Hysteresis.* Journal of Economic Perspectives 6, Winter, pp. 107-132

[23] Economist Magazine (1993). *Why here?* The Economist, February 27, 1993, pp. 28-33

[24] Euromoney (1988). *The Euromoney Country Risk Method.* Euromoney, September 1988, p. 223

[25] Flynn, Julia et al (1994). *Finally, the Payoff From Thatcher's Revolution.* Business Week, February 21, 1994, p. 14

[26] Foust, Dean and Mallory, Maria (1993). *The Boom Belt: There's no Speed Limit on Growth Along the South's I-85.* Business Week, September 27, 1993, pp. 40-48

[27] Freedman, J. and Wever, C. (1979). *Territory and Function.* Edward Arnold, London

[28] Galbraith, Craig (1990). *Transferring Core Manufacturing Technologies in High-Technology Firms.* California Management Review, Summer 1990, pp. 56-70

[29] Gibbs, David (1989). *Government Policy and Industrial Change.* Routledge, New York

[30] Guisinger, S. (ed.)(1985). *Investment Incentives and Performance Requirements.* Paeger, New York

[31] Halkier, Henrik (1992). *Development Agencies and Regional Policy: The Case of the Scottish Development Agency.* Regional Politics & Policy, Vol. 2, No. 3, Autumn 1992, pp. 1-26

[32] Hilhorst, J.G.M. (1990). *Regional Studies and Rural Development.* Avebury, Gower Publishing, Aldershot, U.K.

[33] Hodges, M. (1974). *Multinational Corporations and National Governments: A Case Study in the United Kingdom's Experience 1964-1970.* Farnborough House, Saxon House

[34] Hoover, E.M. (1948). *The Location of Economic Activity.* New York, McGraw Hill

[35] Institution of Electrical Engineers (1992). *U.K. Manufacturing - A Survey of Surveys and a Compendium of Remedies.* IEE, May 1992

[36] Invest in Britain Bureau (1987). *Annual Report*

[37] Invest in Britain Bureau (1996). *Promotional Material*

[38] Isard, W. (1956). *Location and the Space Economy.* John Wiley and Sons, New York

[39] Japan External Trade Organization (JETRO) (1992). *8th Survey of European Operations of Japanese Companies in the Manufacturing Sector.* JETRO, October 1992

[40] Klammer, Thomas (1972). *Empirical Evidence of the Adoption of Sophisticated Capital Budgeting Techniques.* Journal of Business, July 1972, pp. 387-397

[41] Kogut, Bruce (1985). *Designing Global Strategies: Profiting from Operational Flexibility.* Sloan Management Review, Fall 1985, pp. 27-38

[42] Kotter, John (1985). *Power and Influence.* The Free Press, a division of Macmillan, Inc., New York

[43] MacKie-Mason, Jeffrey (1990). *Some Nonlinear Tax Effects on Asset Values and Investment Decisions Under Uncertainty.* Journal of Public Economics 42 (August), pp. 301-328

[44] MacCormack, Alan et al (1994). *The New Dynamics of Global Manufacturing Site Location.* Sloan Management Review, Summer 1994, p. 69-80

[45] Majd, Saman and Myers, Stewart (1987). *Tax Asymmetries and Corporate Income Tax Reform* in M. Feldstein (ed.), "The Effects of Taxation in Capital Accumulation", University of Chicago Press, Chicago and London, pp. 343-376

[46] Markides, Constantinos and Berg, Norman (1988). *Manufacturing Offshore is Bad Business.* Harvard Business Review, September-October 1988, pp. 113-120

[47] Martin, Ron (1993). *Remapping British Regional Policy: The End of the North-South Divide?* Regional studies, Vol. 27.8, pp. 797-805

[48] McDonald, Robert and Siegel, Daniel (1986). *The Value of Waiting to Invest.* Quarterly Journal of Economics (November): 101, pp. 707-728

[49] Metcalf, David (1984). *Employment and Industrial Assistance* in A. Jacquemin (ed.) "European Industry: Public Policy and Corporate Strategy." Clarendon Press, Oxford, pp. 84-97

[50] Metcalf, Gilbert and Hassett, Kevin (1993). *Investment with Uncertain Tax Policy.* Work in progress quoted in Dixit and Pindyck (1994), op. cit.

[51] Munday, M. (1990). *Japanese Manufacturing Investment in Wales.* University of Wales Press on behalf of the Institute of Welsh Affairs, Cardiff

[52] National Economic Development Council (NEDC) (1982). *Direct Inward Investment.* Memorandum by the Secretary of State for Industry to the NEDC, January 1982, NEDC (82) 7. Subsequently published in British Business 26, February 1982.

[53] National Economic Development Office (1982). *Industrial Policy in the U.K.* NEDO (82) 25. NEDO Publications, Millbank Tower, London SW1.

[54] *Numerical Recipes in C*

[55] Ohmae, Kenichi (1985). *Triad Power: The Coming Shape of Global Competition.* The Free Press, a division of Macmillan, New York

[56] Pfeffermann, Guy (1992). *Facilitating Foreign Investment - Some dos and don'ts.* Finance & Development, March 1992, pp. 46-47

[57] Pindyck, Robert (1991). *Irreversibility, Uncertainty and Investment.* Journal of Economic Literature 29 (September), pp. 1110-1152

[58] Porter, Michael (1990). *The Competitive Advantage of Nations.* Harvard Business Review, March-April 1990, pp. 73-93

[59] Porter, Michael (1980). *Competitive Strategy.* The Free Press, a division of Macmillan, New York

[60] Prahalad, C.K. and Hamel, Gary (1990). *The Core Competence of the Corporation.* Harvard Business Review, May-June 1990, pp. 79-91

[61] Price Waterhouse (1994). *Doing Business in the United Kingdom*

[62] Price Waterhouse (1995). 1995 Supplement to 1994 edition of *Doing Business in the United Kingdom*

[63] Robinson, F. (1990). *The Great North.* BBC North East, Newcastle upon Tyne

[64] Rodrik, Dani (1991). *Policy Uncertainty and Private Investment in Developing Countries.* Journal of Development Economics 36 (October), pp. 229-242, North-Holland Press

[65] Schall, L. et al (1978). *Survey and Analysis of Capital Budgeting References.* Journal of Finance, March 1978, pp. 281-287

[66] Scottish Enterprise (1993). *Annual Report*

[67] Strange, Roger (1993). *Japanese Manufacturing Investment in Europe - Its Impact on the U.K. Economy.* Routledge Inc., London and New York

[68] Sugden, R. (1989). *The Warm Welcome for Foreign Owned Transnationals from Recent British Governments* in M. Chick (ed.), "Government Industry Relations Post-1945", Edward Elgar, Gloucester

[69] Twomey, Jim and Taylor, Jim (1985). *Regional Policy and the Interregional Movement of Manufacturing Industry in Great Britain.* Scottish Journal of Political Economy, Vol. 32, No. 3, November 1985, pp. 257-277

[70] Vanhove, Norbert and Klaasen, Leo (1986). *Regional Policy: A European Approach.* Avebury, Second Edition

[71] Weber, Alfred (1929). *Alfred Weber's Theory of the Location of Industry,* University of Chicago Press, Chicago. (First published in German 1900).

[72] Yuill, Douglas and Allen, K. (1986). *European Regional Incentives: 1986. A Survey of Regional Incentives in the Countries of the European Community, Portugal, Spain and Sweden.* Glasgow

[73] Yuill, Douglas et al (1980). *Regional Policy in the European Community - The Role of Regional Incentives.* Centre for the Study of Public Policy, Croom Helm, London

[74] Yuill, Douglas et al (1980-). *European Regional Incentives.* Edited by the European Policies Research Centre, University of Strathclyde, Bowker-Saur, London