

VOLATILITY, FLEXIBILITY, AND THE MULTINATIONAL ENTERPRISE

by

ARUN SUNDARRAM MURALIDHAR

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Signature of author _____
Sloan School of Management
June 1992

Certified by _____
Donald R. Lessard
Professor of International Management
Thesis Advisor

Certified by _____
Jean-Luc Vila
Assistant Professor of Finance
Thesis Advisor

Accepted by _____
James B. Orlin
Professor of Operations Research

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ABSTRACT

Many arguments have been put forth to justify the existence of a multinational enterprise (MNE) that emphasize its ability to diversify business risks. Some of these arguments have been discredited because investors can diversify these risks as well as, if not better than MNEs. However, certain risks that arise from volatility in demand for products, factor costs and tax regimes can give rise to major advantages for the MNE that can internalize real and/or financial flexibility, because firm-level diversification cannot be replicated by investors. When faced with adverse cost shocks, management of the MNE exercises the real and financial options that flexibility provides. By exercising these options, management maximizes the expected future cash flow stream, thereby enhancing the value of the MNE's investment portfolio.

We first show in a partial equilibrium setting that tax regime volatility provides a competitive advantage to the multinational *vis-a-vis* a unational firm or investor-level diversification, because the market for tax shields is incomplete. We then show how multinational firms should value flexibility when tax regimes, factor costs and exchange rates are volatile, and how a valuation of real and financial flexibility impacts strategic decision-making by MNEs.

The first paper demonstrates that the mere existence of asymmetric and changing tax regimes around the world provides a sufficient condition for a unational firm to invest abroad (i.e. provide an additional reason for the existence of a MNE), possibly even in a relatively high tax jurisdiction. We prove that by internalizing tax management and thereby creating the ability to shift some fraction of profits from a high tax to a low tax jurisdiction, a multinational is afforded the opportunity to increase expected firm value above that of an exact set of purely national firms.

The next two papers demonstrate that having operations in more than one country provide MNEs with flexibility, and how static NPV analyses may not capture the value of this flexibility. We argue that the value of a foreign project = NPV of the foreign project assuming that it was a stand-alone project + value of financial and real flexibility that the project provides the parent organization, where we define financial flexibility to be the ability to shift profits to favorable tax locations when tax regimes are changing and real flexibility to be the ability to switch capacity utilization to the lowest cost location when domestic costs and exchange rates are volatile.

We introduce options pricing models to value flexibility and offer an adjusted NPV calculation that incorporates this portfolio of options into the investment decision. In each case, the models are also used to compare competing investment locations using “stylized” tax and wage (and exchange rate) data from some countries and to comment on optimal investment location and capacity choice decisions. While the values generated in our simulations are a first approximation of the true value of flexibility, they provide a benchmark for the potential value of the real and financial flexibility of MNEs. We also attempt to provide a valuation methodology to capture the “true value” of incremental FDI within a MNE environment.

The key result of these papers is that MNEs with flexibility should be more concerned with the degree of correlation of business environments (tax regimes and factor costs) across countries than the country-level variance of these same business costs considered in isolation.

Thesis Committee :

Professor Donald Lessard, Professor of International Management

Professor Jean-Luc Vila, Assistant Professor of Finance

Professor Franco Modigliani, Institute Professor, *Emeritus*

Professor Louis T. Wells, Jr., Professor of International Management

(Harvard Business School)

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I would like to dedicate this thesis to my parents, and I hope that some of their infinite wisdom is reflected in the following pages.

Introduction to the Thesis

Many arguments have been put forth to justify the existence of a multinational enterprise (MNE) that emphasize its ability to diversify business risks. Some of these arguments have been discredited because investors can diversify these risks as well as, if not better than MNEs. However, certain risks that arise from volatility in demand for products, factor costs and tax regimes can give rise to major advantages for the MNE that can internalize real and/or financial flexibility, because firm-level diversification cannot be replicated by investors. When faced with adverse cost shocks, the MNE exercises the real and financial options that flexibility provides, which in turn maximizes the expected future cash flow stream, thereby enhancing the value of the MNE's investment portfolio.

The thesis is presented in two parts. In Part I we show that tax regime volatility provides a competitive advantage to the multinational *vis-a-vis* a unational firm or investor-level diversification, because the market for tax shields is incomplete. In Part II, we show how MNEs should value flexibility when tax regimes, and factor costs/exchange rates are volatile, and how a valuation impacts strategic decision-making by MNEs.

While some of these issues have been discussed elsewhere in the literature on the MNE, the contribution of this thesis is to formalize the analysis, and provide rigorous and stylized economic models of the MNE. The central idea that is explored in these papers is that, within a MNE's business environment, volatility in local environments (considered in isolation) may be of less importance than the degree to which those local environments are correlated with business environments in another country. With these models in place, we are able to make a contribution to the internalization theory of FDI (or the theory of the existence of the MNE), and draw conclusions about optimal investment decision making by managers in the MNE. We then use data on tax rates and wages (and exchange rates) to test the implications of these models, and even obtain a seemingly counter-intuitive result that a US-based MNE might prefer to invest in Italy - a relatively high tax country - than invest in a similar project in Canada - a relatively low-tax country.

CHAPTER 1

“Tax Regime Volatility, Tax-Saving and the Value of Multinationality”

Abstract

This paper shows in a partial equilibrium setting how the variability of tax obligations on corporate profits (either from changes in statutory tax rates or from changes in profitability of operations within specific tax jurisdictions) coupled with incomplete external markets for the sale of tax shields provides a necessary and a sufficient condition for FDI, or alternatively provides an additional reason for why firms are multinational. We argue that if tax regimes are variable and less than perfectly correlated, then tax saving is possible and firms with international business increase expected firm value more by investing abroad than by investing at home. This result holds even if we assume that a relatively small fraction of pretax profits can be shifted to the favorable tax location. Further, firm-level diversification dominates portfolio investment by individual investors. Additional conclusions include the result that firms may invest abroad in anticipation of possible future tax rate changes at home; that firms may invest abroad even if the expected after-tax rate of return at home is greater than the after-tax rate of return abroad; and that changes in tax rates lead to profit-shifting within the multinational firm and not necessarily to new capital flows to the country with the higher after-tax rate of return. This paper concludes with some policy implications from viewing FDI from such an approach.

" The proprietor of land is necessarily a citizen of a particular country in which his estate lies. The proprietor of stock is properly a citizen of the world, and is not necessarily attached to any particular country. He would be apt to abandon the country in which he was exposed to a vexatious inquisition, in order to be assessed to a burdensome tax, and would remove his stock to some other country where he could either carry on his business, or enjoy his fortune more at ease. By removing his stock he would put an end to all the industry which it had maintained in the country which he left."

Adam Smith (1776)

Introduction

Theories to explain foreign direct investment (FDI, alternatively DFI) have abounded following Hymer's pioneering work in 1960, and each new theory has drawn on certain aspects of doing business in an international context to provide a credible hypothesis for why firms expand across geographical boundaries in spite of the transactions costs incurred. A vast majority of these theories have expressed the optimality of internalizing transactions in the presence of market imperfections in the global economy. These imperfections may be natural or else created by the firms themselves, which they then exploit. Interestingly, most of the widely accepted theories, with the possible exception of Aliber's Currency-Area hypothesis¹ and Rugman's diversification of earnings theory², dwell on the aspects of product markets, both intermediate and final, that cause national firms to become multinational.³ Lessard (1979) analyzes this trend and proposes that financial factors have not been suggested because financial markets are deemed to be more efficient than markets for real goods and services. This in turn reduces the benefits of the internal transfer mechanisms.⁴

In this paper, we will provide an explanation for FDI that is not dependent on imperfections in the markets for products or factors of production. We show

¹ Aliber (1970).

² Rugman (1979).

³ Refer to Appendix I for an abbreviated review of the most widely accepted theories. Also refer to Buckley and Casson (1985), Calvet (1981), Dunning (1988) and Rugman (1979) for more detailed reviews.

⁴ Lessard (1979), page 118. The crux of most financial theories of FDI is to show how imperfections in markets prevent investor-level diversification from dominating firm-level diversification.

that even if real markets are perfectly competitive, a firm might invest abroad if tax regimes around the world are changing and less than perfectly correlated. The result we propose is entirely consistent with the firm-value-maximizing goals of rational management. Essentially, we will show how real configuration decisions will be affected by financial/taxation issues.⁵ We do not argue that this approach is mutually exclusive with Hymer's (1960) approach, but instead, that the ability to engage in tax management under the conditions outlined below may be a significant motivation for foreign investment.

Dunning (1975) recommends that a complete theory for FDI (or alternatively for the existence of a multinational firm) must show why a parent firm would want to own a locationally diversified portfolio of sub-units (i.e. subsidiaries around the world), thereby internalizing transactions that would otherwise have been conducted at arms' length. We will use this framework, known in the literature as the OLI (Ownership-Location-Internalizing) approach to present our theory of FDI. Further, a complete theory for the existence of the MNE must show why the MNE is preferred, as a vehicle to diversify business risks, to diversification of portfolios by individual investors.

There are three basic questions that need to be answered. First, what is it about the foreign firm and the investing environment that allows foreign firms to have an advantage over local manufacturers in acquiring an asset? The firm specific or internal endowments (e.g. technology) are called Ownership Advantages, and advantages that are external to the firm and that are derived from the host country are called Locational Advantages. Second, are the advantages associated with internalization such that the rents that accrue to the parent from FDI are greater than the rents that accrue from any other (arms' length) alternative e.g. licensing, joint ventures or exports? -

⁵ The importance of markets for products and factors should not be underestimated, but as markets around the world become more competitive, the insight that a theory that emphasizes tax-saving provides may have increased significance. In addition, taxes and cost of goods sold are the two major expenses for any firm and hence it is important to investigate the impact of taxes on real activity.

(Benefits from Internalizing)⁶ Third, why can't investor-level diversification replicate or dominate firm-level diversification?

While other work has highlighted the fact that MNEs (multinational enterprises) have the ability to lower their global tax liability, this paper explicitly outlines the conditions under which foreign direct investment might be undertaken for tax saving reasons, and shows why investor-level diversification provides less value than investing in a MNE. Buckley and Casson (1976), for example, point out that there is a benefit to internalizing transactions when external markets are imperfect. With respect to taxes, they state that the benefit to internalization is the ability to minimize the impact of government intervention through transfer pricing.⁷ Therefore, the key contribution of this paper is to clearly outline the conditions relating to taxation and the MNEs that provide additional justification for the existence of the MNE. Thereafter, we draw conclusions about the allocation of real activity and financial profitability by the MNE, in a world where tax regimes are changing and are less than perfectly correlated, and where external markets for the trading of tax shields are incomplete.

Section I provides a more detailed description of the key ideas and rationalizes the choice of a financial/tax-saving explanation for FDI. Section II discusses work by scholars that address the issue of taxes and foreign investment. Section III provides a simple model to demonstrate the key insights, while Section IV tests the model with specific parameter values. Section V considers possible extensions to the model. Section VI summarizes the work in this paper and posits policy implications from viewing FDI in such a framework.

⁶ Adapted from Dunning (1988), pg. 20.

⁷ This view is not new, and has even been proposed by Kindleberger (1969). However, they suggest that the benefit stems from the non-existence (of the availability) of prices in the external market for goods traded within the MNE. Further, they state that the benefits also depend on, "the characteristics of the fiscal systems in the various regions linked by the market," but do not dwell deeper into what those characteristics are. See page 46.

Section I

"At the highest level of abstraction, foreign investment is motivated by an increase in net worth of a firm as a result of its achieving a higher rate of return from marginal investment abroad than from domestic investment alone."⁸ The value of a firm is the present discounted value of its global after-tax cash flows.

$$V = \sum \frac{\text{After-tax CF}_t}{(1+r)^t}$$
 where CF = global cash flows, r = tax-adjusted discount rate and t is the time parameter. Hence, there are three components to the value of the firm; namely, pre-tax cash flows, tax disbursements and the discount rate. While a national firm may have control over only its cash flows and its discount rate, a multinational firm can gain an extra degree of freedom because it has the ability to minimize its global tax liability through the effective use of its international financial network.

We show that if tax regimes are variable, and less than perfectly correlated,⁹ and if the external market for tax shields is incomplete, national firms may find that investing in more than one country may be preferred to investing locally.¹⁰ Further, if the external market for trading tax shields is incomplete, the expected value of a MNE will be greater than the aggregate value of an exact set of purely national organizations. If this is the case we can provide an additional argument for the existence of a MNE, because an investor will find that investing in the MNE is more valuable than purchasing shares in a replicating set of national organizations.

The critical idea is that a national firm will be unable to change its tax liability (without changing earnings) in response to any changes in domestic tax policy. On the other hand, by planning for future policy changes and by

⁸ Rugman (1979).

⁹ In the Appendix to Chapter II we provide tax rate data for the US. and a number of developed countries to show that this is not an unreasonable assumption. For example, US. tax rates have been more variable than most other countries during 1984-1990, and it is clear that there is less than perfect correlation between the US. and countries like Australia, Germany, Denmark, Japan and Italy. However, tax rates in the UK. and Canada seem to be closely correlated to tax rates in the US.

¹⁰ We emphasize that the external market for tax shields is incomplete rather than non-existent. This is true because lease contracts can be used, in certain situations, to trade tax shields across tax jurisdictions.

creating a corporate entity in a country with a tax regime that is not perfectly correlated with that of the home country (Locational Advantages), the firm creates a network within which it can move profits either through increased economic activity or through the shifting of profits¹¹ to the location of choice (Ownership Advantages). By owning assets in different tax/ geographical jurisdictions, multinational firms purchase the option to be flexible. This location strategy allows them to minimize their global tax liability by internalizing, and controlling completely, specific transactions which would otherwise have been conducted at arms' length.¹² Managers in MNEs (multinational enterprises) are now in a better position to minimize the firm's tax liability and maximize firm value than if the firm was national.

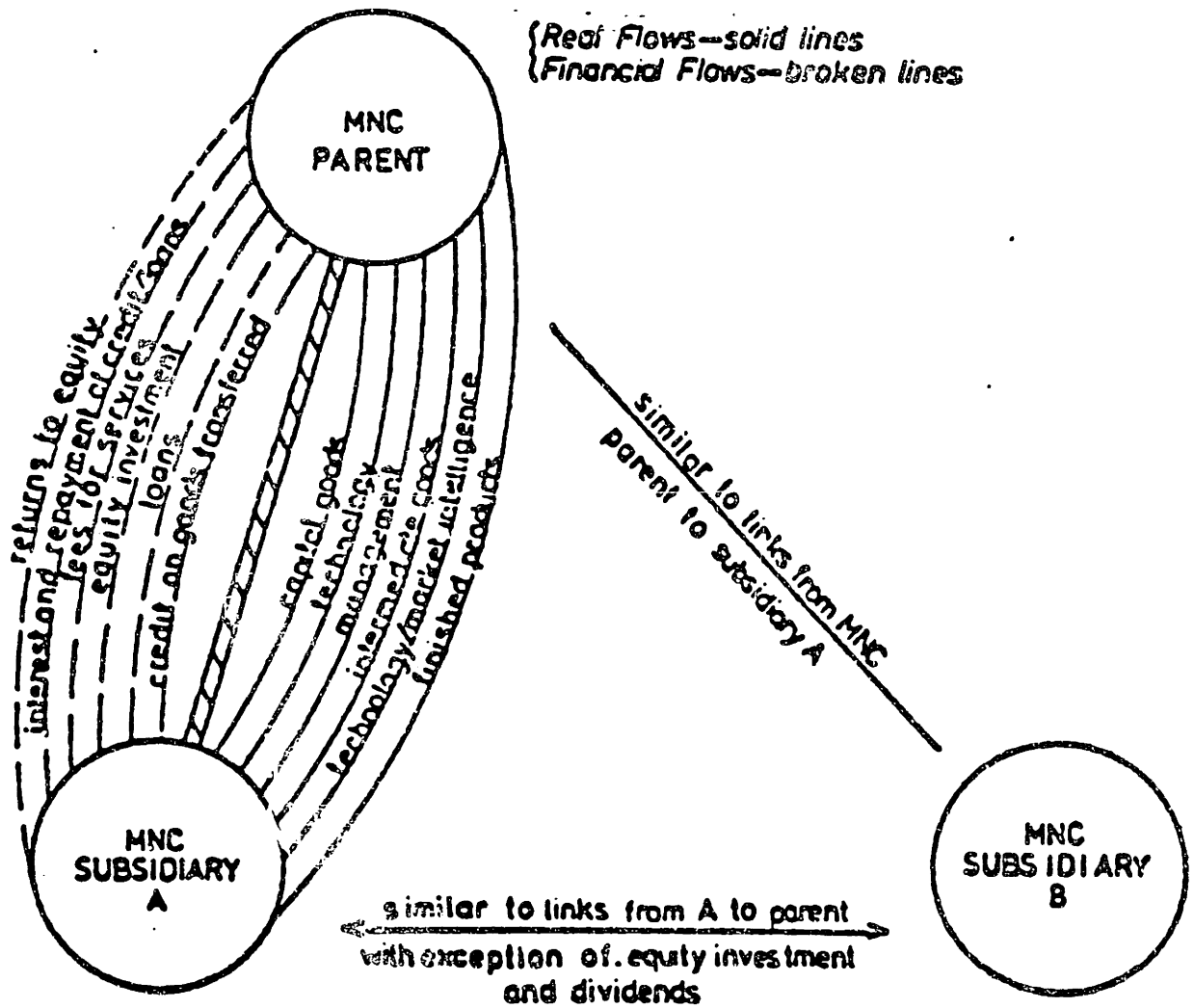
In the remainder of this section we will attempt to show how changing tax regimes could affect firm location decisions (domestic versus foreign; investing in relatively high tax regions), capacity choice decisions (how much to invest in each location) and the choice of operation (wholly-owned subsidiary versus joint venture or licensing agreement). Finally, we will demonstrate why domestic investors in the foreign country will not want to acquire this asset, and why diversification by the MNE is preferred to diversification by an investor.

We begin by assuming that managers attempt to maximize the value of their organization by maximizing the present discounted value of the after-tax cash flows that the company's assets generate. In the case of the MNE, this is achieved through a two-step procedure that allows the management of the firm to invest in an optimal fashion so as to maximize earnings, and then allocate profits among its multiple locations so as to minimize tax payments. National firms, on the other hand, do not have the ability to actively manage

¹¹ For example, this could involve changing or selecting optimal transfer prices on inter-company goods flows, and/or terms on which money is lent to the subsidiary.

¹² For example, the MNE has some flexibility in laying down the terms of exchange between constituent units for transactions involving either goods or finances (i.e. debt and equity infusion into subsidiaries or dividend repatriation). Refer to Figure 1 for a diagrammatic representation of possible transactions between parent and subsidiary or between two subsidiaries. Refer to Lessard (1979), pp. 103-108 for a more detailed description of the multinational financial system.

Figure 1
The Multinational Corporate Financial System



Source : Donald Lessard (1979), "Transfer Prices, Taxes and Financial Markers : Implications of Internal Financial Transfers within the Multinational Corporation," in *The Economic Effects of Multinational Enterprises*, ed. R.G. Hawkins.

their tax liability without changing earnings, and cannot purchase tax shields in an external market because such a market for tax shields is either non-existent or incomplete.

In order to provide a theory for FDI we must show why investing in capacity abroad is strictly preferred to remaining national. As a logical starting point we consider a national organization with international business that is faced with increased demand for its products, which cannot be served by existing factories.¹³ Should the firm build its new plant in a foreign country or else invest again at home? Management will arrive at a decision after evaluating which option adds the most value to the existing organization.

By making an investment in any country, an organization enters into an unwritten contract with the host country. The nature of this so-called contract is as follows: In exchange for being given the opportunity to invest in any country, the enterprise is expected to pay taxes at the corporate tax rate (unless otherwise agreed upon) on locally generated profits.

Management is always aware that since the investment is irreversible, the possibility of *ex-post* changes in host government policy poses a threat to the receipt of cash flows. Two actions in particular, by host governments, decrease the value of the flows received by the organization. On the one hand, the host government can nationalize the project (subsidiary, branch, joint venture etc.) and deprive the parent of any future cash flows that the facility generates. On the other, a less drastic step, yet by no means insignificant, the host government can change the rules of the game *ex-post* and receive a larger share of the returns from the investment. This it can do by increasing the corporate marginal tax rate¹⁴ on a firm- by-firm basis

¹³ This approach coincides with the demand aspects of the Product Cycle Model of Vernon (1971). BMW is presently considering expanding capacity outside Germany for the first time since its inception because of an increase in demand. Some of the reasons suggested for this move have been rising costs and also steep corporate tax rates in Germany. See Protzman (1992) - New York Times.

¹⁴ Alternatively, the effective tax rate as described by King and Fullerton (1984). The effective tax rate includes other taxes like sales tax and excise taxes and accounts for deductions.

(commonly seen in the mining industry) or else by increasing the corporate tax rate that all investors must adhere to for profits realized locally.¹⁵

An astute manager should internalize these two eventualities in his/her decision-making process and try to provide the organization with as much insurance as is merited by these threats (and/or his/her own risk aversion). The literature on FDI is rich with examples and suggestions on how to protect a new investment from nationalization.¹⁶ Since this possibility is most commonly encountered in developing countries, firms generally enlist the support of international agencies like the World Bank or the IFC (International Finance Corporation) and also involve national governments and large international banks in the project. It is hoped that the involvement of these parties will put a damper on any desire that the host government might harbor to appropriate the project. Alternatively, where such a threat exists, the foreign investment is structured so that it is dependent on investments in other countries either for inputs or for markets for the final product.

Though using third parties or assets dependent on other assets outside the local jurisdiction helps reduce the probability that the whole project is gobbled up by a rapacious developing host country, these methods are essentially ineffectual in preventing the host governments in both developed and developing countries from collecting a larger share of profits, via an increase in corporate marginal tax rates, after the investment has been made.

Since explicit bargaining over marginal corporate tax rates rarely takes place, if management of a national firm realizes that an exogenous increase in marginal tax rates¹⁷ lowers the value of the firm to the extent that pre-tax cash flows are unchanged, then they should internalize this aspect into their capacity expansion decision. Should they choose to let the firm be national, they will be unable to moderate the share that they pay the government *ex-post* through the exogenous increase in the tax rate, and must submit

¹⁵ Tax rates may be raised to increase tax revenues across the board and not necessarily directed towards foreign firms, but this action has the effect of reducing the value of the firm or future investment opportunities.

¹⁶ References include Kindleberger, Moran et al, and Vernon.

¹⁷ We will attempt to discuss bargaining over taxes and endogenous taxes in another paper.

passively to any changes in domestic policy. This will force the firm to invest sub-optimally!¹⁸

Alternatively, a firm with international business could use this opportunity to invest in a foreign country that has an independent or less than perfectly correlated tax regime.¹⁹ This firm now has the capacity to diffuse the ability of the home government (or any one government) to extract higher taxes *ex post*. By investing in another country the firm creates an international financial network that allows it to transfer profits, to the country that offers the most favorable tax treatment. Alternatively, the firm can lower its global tax payments by moving profits, within a band of reason, from subsidiaries in countries where they are showing profits to others that are reporting losses. While, the benefits from profit shifting will differ under a residency tax system *vis-a-vis* a territorial based tax system, it will be unequivocally beneficial as long as deferral of taxes has some value.²⁰ At a very minimum, one can think of the foreign investment as a form of hedging against adverse changes in domestic tax regimes.²¹

The international financial network is acquired by investing abroad and allows the firm greater flexibility in designing contracts among subsidiaries and creates an internal market for reducing the tax liability. This increased flexibility is valuable because it allows the management to increase the value

¹⁸ The optimal level of investment is the level chosen either when there is no variability in tax rates or when future tax rates are known with certainty. We will show in sections III and IV how uncertainty leads to sub-optimal investment.

¹⁹ At this stage we will ignore all real aspects with a broad wave of hand by assuming that the return from the investment is identical in all countries. This ignores the possibility that the foreign location may provide this specific firm with a higher return than another firm for any number of reasons. On the other hand, this approach suggests that we can have FDI even if markets for final goods and inputs are perfectly competitive. If we allow for imperfect competition in these markets, the benefits to becoming multinational may be more pronounced.

²⁰ Countries that follow the residential system of taxation tax the MNE for global profits earned, but provide tax credits for foreign taxes paid. Under the territorial system of taxation, countries assess their taxes on the MNE only on local profits earned, and leave the taxation of foreign profits to foreign governments, but tax dividends. The US, Japan and the UK follow a residency system, while France, Belgium and the Netherlands have a territorial system. Some countries like Germany and Canada have a hybrid system of taxation. Presently, the US is effectively pursuing a territorial treatment of foreign source income because of the relatively low tax rate in the US.

²¹ For a detailed description of the tax laws in the US and methods to reduce tax liabilities refer to Paul Bodner, "International Taxation," and Scholes and Wolfson - Chapters 13 and 14.

of the firm through tax management (which in the extreme is tax evasion). In certain circumstances, the foreign investment can be considered a strategic move with purely financial implications, even if the real benefits that accrue to the organization that have been highlighted by previous theories of FDI do not exist.

Once the investment takes place, management has a legitimate organizational framework within which the transfer of profits between countries can be rationalized as being a necessary part of the global business, within the boundary of the law. Transactions between the constituent units can be designed in anticipation of future tax regime changes. The synergies that the new investment has with existing investments creates a situation where expected firm value is higher than it would be if the firm was national, thereby validating this as a theory for FDI. Hence, where such financial manipulation is possible and valuable, real configuration decisions can be made for purely tax-saving reasons.²²

Investing abroad protects the MNE from adverse tax rate changes and the cost of this flexibility/risk-reduction strategy includes the cost of doing business from a distance and also the expected cost of shifting profits i.e. the home and host country may try to monitor the behavior of MNEs and impose fines when they detect transfer-pricing transgressions. With this investment, the firm gains not only increased flexibility along real aspects of production, but also increased bargaining power with both governments.²³

Moreover, we can use this framework to draw implications about investment levels and the location of investments. Uncertainty about future tax rates at home makes another investment by a purely national firm seem risky because of the uncertainty surrounding the *ex-post* after-tax rate of return. This uncertainty distorts investment decisions for national firms, in turn leading to lower expected firm value. The MNE, on the other hand, reduces the ability of any one government to tax away a large share of locally

²² In addition to reducing the risk of a substantial lowering of future after-tax cash-flows through profit-shifting, firms may also shift production activity in order to generate profits in the low tax regions. Also refer to Kindleberger (1969).

²³ To be discussed in Section VI.

generated profits. Further, by protecting itself against these changes in fiscal policy, the MNE is able to hedge the uncertainty of future tax rates, invest closer to desired levels and increase the expected value of the firm.

Ideally, the firm should invest in a lower tax region, but it could also be rational to invest in a higher tax region when pre-tax rates of return are the same in all countries. This seemingly counter-intuitive result follows if there is some probability that tax rates in the home country will be raised above the tax rates in the foreign country, or that the tax rate in the foreign country will be reduced below that of the home country. This implies that what is today a relatively high tax region could in the future be a relatively low tax region, and hence the firm may have to evaluate the option value of waiting before investing in any country.²⁴²⁵ In this situation, management could be investing in options which it may never need. However, *ex-ante*, purchasing these options may be rational much like purchasing options that are not in the money. Using this approach, we can conclude that investment may be made in anticipation of possible changes in domestic tax policy.

Domestic investors in the foreign country do not acquire the same asset because it is not as valuable to them as it is to a firm domiciled in another country. To the MNE, this asset (e.g. factory) is an integral part of a much larger corporate organization. Given the synergies (from reducing tax disbursements) that exist between the individual parts, the expected return to the foreign investor will be greater than the expected return for a purely domestic investor, in turn raising the price that the MNE is willing to pay for the asset. Moreover, investors will find that investing in the MNE provides more value than purchasing shares in a replicating set of national firms in the two countries. This result holds because of the MNEs ability to internalize tax management in the presence of an incomplete external market for sharing risks associated with tax rate changes.

²⁴ The MNE will attempt to locate costs in the high tax region and incomes in the low tax region. This ensures that even if tax rates at home are not raised in the immediate future, the tax burden in the foreign country is not too severe.

²⁵ Refer to Pindyck (1988) for a review of the literature on the option value of waiting when business environments are volatile. Models have not been specified to value the option to wait when tax regimes are stochastic, but Muralidhar (1991b) values multinational financial flexibility when this is the case.

Firms might be tempted to create "shell" operations in tax havens rather than invest in production facilities in order to lower their tax liability. However, the existence of a production facility (rather than a joint venture or a licensing agreement) gives the firm more degrees of freedom in manipulating the declaration of profits as discussed earlier in reference to Figure 1. Further, the creation of a production facility also provides real flexibility that allows management to choose where to produce the bulk of total output when the cost of immobile factors is variable.²⁶ Finally, tax authorities have ensured that laws are in place to prevent the funneling of profits through a pseudo-operation. For example, repatriation of profits from tax havens are tax exempt only if manufacturing actually takes place in these countries.²⁷ Also, in the United States under Subpart F, foreign source income has to be separated into five baskets to ensure that high-tax passive income is not aggregated with income from business activities, which is taxed at a lower rate.

To recapitulate briefly, the variability of corporate tax obligations, either from changes in statutory tax rates or from changes in the profitability of operations within different tax jurisdictions when taxes are convex, coupled with incomplete external markets for the trading of tax shields creates a condition whereby investing abroad may be preferred to investing locally. A firm might find it advantageous to create an entity abroad, possibly even in a country with a relatively high tax rate, and internalize tax management. This investment protects the MNE from the increases in tax rates at home that may lower the value of the firm. Further, diversification by the MNE to mitigate these risks is clearly preferred to diversification by individual investors.

²⁶ Refer to Muralidhar (1991c) for a valuation of operational flexibility.

²⁷ The US. has adopted "look-through" rules to determine where profits were originally generated to prevent tax avoidance. While Puerto Rico is not a foreign location, the US. has enacted several laws to prevent MNEs from using Puerto Rico as a tax haven, and repatriation of profits from Puerto Rico are tax exempt only if manufacturing activities are conducted in Puerto Rico. This law illustrates the IRS's desire to reduce financial manipulation. Also refer to Delmar (1991) for a description of the problems that have to be faced by MNEs when transfer pricing transgressions are detected by the IRS.

We are able to show that the expected value of the MNE is greater than that of a national firm, even when the fraction of profits that can be shifted to the favorable tax location is relatively small.²⁸ Further, if the first-best level of investment is the level that would be optimal if tax rates in the future were either unchanged or known with certainty, then we can show that uncertainty about future tax rates will cause the firm to invest sub-optimally at home. However, by investing abroad and internalizing tax management, an MNE is able to invest more effectively than a national enterprise, thereby increasing the expected value of the firm. Real decisions could be influenced by purely financial/tax-saving issues and in this fashion, the expected value of a MNE may be greater than the value of a firm that is national.

²⁸ In Table 1 we prove this result assuming that the MNE can shift only 10% of pre-tax profits to the favorable location. A generally acceptable value for this variable could be 20%. Refer to Section IV, Table 1.

Section II

In a 1979 review of the literature pertaining to taxes and MNEs, Lessard noted that the issue of interest in the review was to examine the extent to which real investment, production and trade decisions and the distribution of benefits resulting from these decisions were changed because of the MNE's ability to shift funds and profits internally.²⁹ In the discussion above, we took a step backward to show how factors related to shifting funds and profits internally could cause a firm to be multinational in the first place, thereby making a statement about real investment and production decisions.

The fact that tax regimes are dynamic and not static, and that a market for tax shields is incomplete provides us with some interesting theoretical results.³⁰ Moreover, when they are less than perfectly correlated, firms with international business may do better by straddling two countries rather than by being strictly national. Strands of the FDI literature have inspected various facets of the tax aspects of MNE behavior.

The literature is replete with discussions of how MNEs can minimize their tax liability.³¹ Surprisingly, this is the first approach that rigorously outlines the conditions under which tax factors could be the sole motivation for foreign investment or the existence of a MNE. By recognizing that the MNE is able to bridge an incomplete external market that exists for the trading of tax shields, especially when tax regimes are volatile, we are able to tie our explanation to the firm-value-maximization goals of rational management and investors.³²

Horst (1971) demonstrated how an MNE, through an appropriate selection of transfer prices, could maximize the value of a two-country firm in the presence of tariffs and taxes, but does not use the same setup to show why a

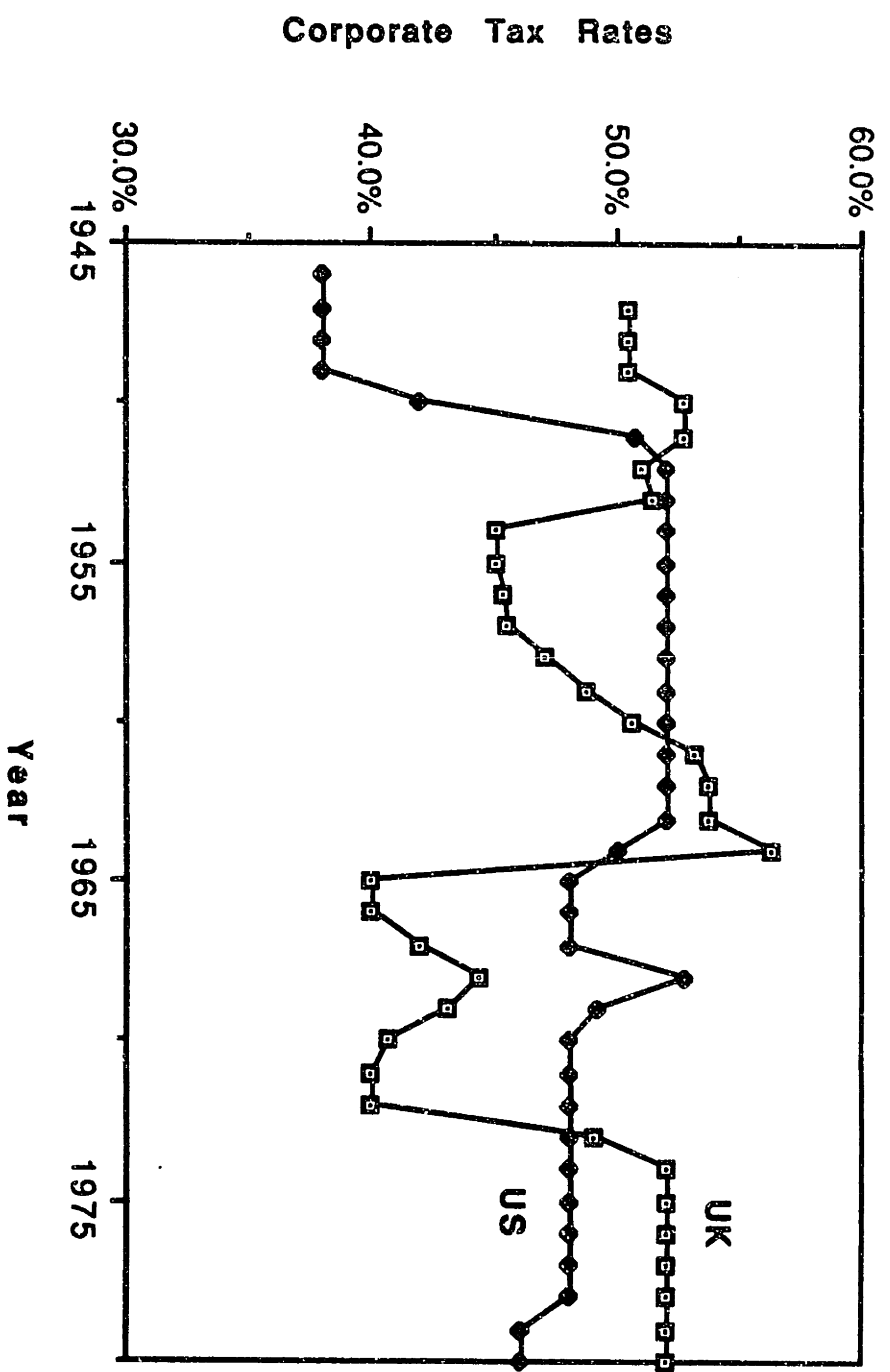
²⁹ Lessard (1979), page 123.

³⁰ Most discussions of taxes and MNEs fail to recognize that tax rates can change quite frequently. Graph 1 which plots US and UK corporate tax rates for 1947-80 shows clearly that this is not the case. Hence it seems obvious that any discussion of taxes and MNEs should include the possibility that tax rates in all locations are subject to change.

³¹ See Caves (1982) for an excellent review.

³² This paper suggests a logical possibility rather than an economic fact, that tax factors could lead to FDI or the existence of a MNE.

Graph 1 - Corporate Tax Rates in the US and UK
(1947 - 1980)



Source : King and Fullerton (1984)

firm might want to be multinational. In other work Horst (1976, 1977) empirically demonstrates how certain changes in US tax policy may have no effect on real decisions, but would cause a MNE to shift revenues because of new incentives created for profit shifting. Lessard (1979) also provides a brief review of some normative models and descriptive studies of MNE tax arbitrage, and also empirical studies of MNE tax-related behavior.³³

Dunning (1988) argues that MNEs can maximize post-tax profits when corporate tax-rates differ between countries since a number of transactions can be internalized.³⁴ Buckley and Casson (1985) state that the MNEs have an incentive to minimize government intervention through transfer-pricing, in turn reducing the overall tax liability by imputing high mark-ups in the lowest tax countries and by locating operations in low-intervention tax-havens.³⁵ Hines and Rice (1990) report that the behavior of US firms in 1982 suggests that American companies take advantage of tax-havens by reporting extraordinarily high profit rates on both their real and financial investments in these locations. Harris *et al* (1991) perform an empirical examination of a number of US MNEs and conclude that they move profits from high tax regions to the US and from the US to low tax countries. They also conclude that this activity lowers the global tax liability for large MNEs (with extensive multinational networks) and appears to lower the US tax liability as well.

The other significant strand of this literature is the one with a more empirical bent that investigates the effect of changes in tax policy on FDI. These papers attempt to draw conclusions about international capital movements by testing whether changes in tax policy stimulate international capital flows through changes in the after-tax rate of return. Hartman (1981,1984,1985) pioneered this branch with a series of articles and his work has now been extended by Boskin and Gale (1987), Young (1988), Newlon (1987), Slemrod (1990) and Jun (1990). The common thread in all these papers has been the attempt to detect whether the relationship between tax policy and FDI (further broken down into FDI financed by retained earnings or transfers from abroad)

³³ Specifically, this article reviews the Horst papers and Kopits (1972,1976b) which deal with the choice of royalties or dividends for remittances to the parent.

³⁴ Page 24.

³⁵ Page 10.

is robust. Not surprisingly, there is less conformity in their results as some found US tax policy to have a significant effect on total FDI or FDI funded from transfers from abroad or FDI funded through retained earnings or some combination of the above, while others detected results quite to the contrary.³⁶

Finally, in a recent paper, Scholes and Wolfson (1990) conclude that the 1986 Tax Reform Act made the US a tax haven relative to many countries. The tax law reduced implicit taxes while raising explicit taxes, and this tax change favored companies that were highly taxed because they will receive tax credits on explicit taxes paid and not on implicit taxes paid. They also argue that the 1986 Act favored acquisitions by foreigners because the Act raised shareholder level tax on capital gains which would prove to be a negative for US firms acquiring other US firms, while this might not be the case for a foreign investor purchasing US assets.

It is rather surprising that economists have recognized that tax-management can increase firm value, but have ignored the possibility that becoming multinational for purely tax-saving reasons is consistent with the goal of maximizing the value of the firm.³⁷ From this approach we are able to conclude that, under certain conditions, foreign investment might take place in anticipation of possible changes in tax rates. We also conclude that firms should look at the contribution of a project to total firm value rather than compare after-tax rates of return.³⁸ Moreover, if firms are multinational prior to tax rate changes, changes in tax rates will only lead to profit shifting, rather than new capital flows to the country with the higher expected after-tax rate of return. In the next section we provide a simple model to illustrate the benefit to being multinational.

³⁶ Caves (1982), reviews the literature on taxation and the MNEs. In addition to reviewing some of the above, this chapter discusses the welfare implications (across countries) of corporate income tax policies. See Chapter 8.

³⁷ Scholes and Wolfson (1990) hint at such a result, but do not state it explicitly. Moreover, they ignore the possibility that firms react in anticipation of domestic policy changes.

³⁸ In Section IV we are able to show why rational management might invest in a foreign project with a lower expected after-tax rate of return than that of a similar domestic project. In Muralidhar (1991b) we demonstrate a similar result by showing how a US.-based MNE might prefer a project in Italy (relatively high tax location) to a similar project in Canada (relatively low tax jurisdiction). In Muralidhar (1991b) we assume that tax regimes around the world are stochastic.

Section III

In this section we will provide the basic assumptions for the model, and then demonstrate how a simple model in this format provides us with the results described in Section I above.

Assumptions

- A.1 Consider an infinite period framework. At the start of period 1 a firm with international business makes an investment at home.
- A.2 This firm invests in the home country (say country A) at the start of period 1 with the knowledge that at the end of period 2 tax rates might be raised from τ^A to τ_H^A with some probability p , and remain unchanged with probability $(1-p)$.
- A.3 The objective of management is to maximize the value of the firm i.e. maximize the discounted sum of global after-tax cash flows.
- A.4 Investment technology is such that an investment of I yields a pre-tax profit $K(I)$ at the end of every period for an infinite number of periods ($K'(I)$ = per period rate of return on investment; $K' > 0$ and $K'' < 0$).³⁹
- A.5 An investment of I costs $C(I)$ to install ($C(I)$ is a sunk cost) and $C(I)$ must be expended at the start of the period when the investment is made. We will assume that $C(I) = I$ implying that $C'(I)$ is equal to unity (where the prime denotes the derivative with respect to the argument in the bracket).
- A.6 At the start of period 2 the firm decides to make an additional investment.⁴⁰
- A.7 The new investment can be made in any country that the firm does business in. This assumes that the infrastructure to support

³⁹ If we wanted to incorporate some of the theories of market imperfections, we can argue that this firm has the technology or a patent that allows it to earn $K(I)$. Other firms can only earn $\Psi(I)$, where $\Psi(I) < K(I)$ for every I . This approach will not change the results of the model. However, with this approach we may be able to show why other firms in country A cannot acquire this asset in country B.

⁴⁰ If we had allowed for differentiated products, then we could argue that the demand for the firm's product increased in the second period. This would be in keeping with Vernon's Product Cycle Model.

the investment exists in all the countries. The firm incurs no additional cost from maintaining a foreign operation.

- A.8 For simplicity assume that all factor, product and financial markets are perfectly competitive. Further, assume that there are no tariffs or transportation costs. This would imply that pre-tax cash flows and costs of investing are the same in every country. (This implicitly ignores all foreign exchange issues)
- A.9 The tax rate in country B, τ^B , is not expected to change. To make the model more interesting we will assume that $\tau_H^A > \tau^B > \tau^A$.
- A.10 Firms can transfer profits between countries. Define T_j^i to be the profits transferred from country j to country i in any period. We should note that this is most like to occur when the effective marginal tax rate in country j is greater than the effective marginal tax rate in country i. An obvious assumption that we make about T_j^i is that $0 \leq T_j^i \leq K(I^j)$.⁴¹
- A.11 The amount that can be transferred from country A to country B is a function of the level of investment in A.

$$\left(\frac{dT_A^B}{dI^A} = \frac{dT_A^B}{dK^A} * \frac{dK^A}{dI^A} \text{ Assume } 0 \leq \frac{dT_A^B}{dK^A} \leq 1 \text{ (from A.10); which implies that } \frac{dT_A^B}{dI^A} \geq 0 \text{ (Since } \frac{dK^A}{dI^A} = K'(I^A) \geq 0 \text{ from A.4)} \right)$$

For simplicity assume the profits transferred from country B to country A is independent of the level of investment in A. i.e. $\frac{dT_A^B}{dI^B} = 0$.

A functional form that will satisfy these conditions is $T_A^B = \gamma K(I^A)$, where $0 \leq \gamma \leq 1$ or more explicitly, firms shift some fixed fraction (γ) of profits from high tax regions to low tax areas.⁴²

⁴¹ This model is slightly unrealistic because we assume that some fraction of the profits can be shifted from one unit to another without clearly addressing the limitations to this activity. Transfer prices on cross-border goods flows are difficult to change and typically must be uniform across different units within the firm. However, there are other avenues through which management can shift profits to the most favorable tax location as explained in Section I. I thank Prof. Lessard for this point.

⁴² This formulation leaves γ unbounded, but we compensate by assuming in our calculations that $\gamma = 10\%$, and compare our results when we assume that $\gamma = 30\%$. Refer to Table 1.

- A.12 Taxes are charged on accounting profit and not economic profit, and are collected at the end of each period. System of taxation in country A is territorial.⁴³
- A.13 An external market for trading tax shields does not exist.

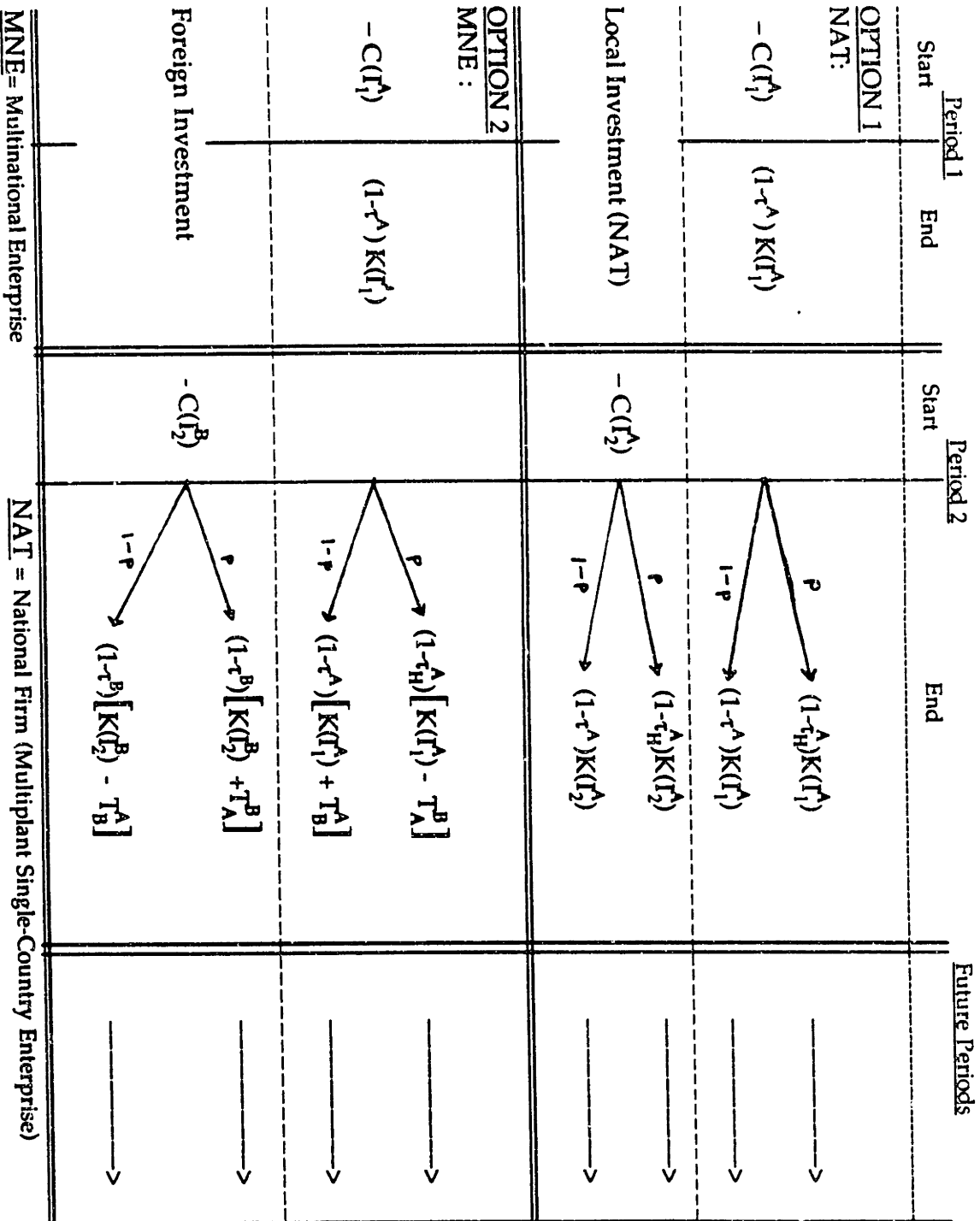
Timing

Refer to Figure 2 for a graphical demonstration of the timing of the moves and returns from the investment strategies.

⁴³ The approach for a residency based system will be slightly different as we will need to incorporate the importance of foreign tax credits etc.

INVESTMENT OPTIONS AND PAYOFFS

Figure 2



The Model

There are two scenarios that we need to consider.

OPTION 1 : Invest twice in country A (i.e. stay uninationl).

For the first investment, management chooses the optimal level of investment (I_1^A) such that it maximizes the expected net return. The expected net return is equal to the expected after-tax cash flows (appropriately discounted as this is essentially a perpetuity) minus the cost of investment. If the firm is national, the expected after-tax cash flow at the end of period 2, which we will refer to as $E(I_1^A)$, is

$$(1) \quad E(I_1^A) = p(1-\tau_H^A) K(I_1^A) + (1-p)(1-\tau^A) K(I_1^A) = K(I_1^A) [1-\tau^A - p(\tau_H^A - \tau^A)]$$

where (I_t^A) is the level of investment in country A made at time period t. Note that

$$(1') \quad E'(\bullet) = K'(I_1^A) [1-\tau^A - p(\tau_H^A - \tau^A)]$$

Since the firm will expect to receive $E(I_1^A)$ in every future period as well, we can treat it like a perpetuity and hence the (expected) present discounted value of all cash flows after t=1 will be

$$(2) \quad \frac{\beta^2}{1-\beta} E(I_1^A),$$

where β is the discount factor and $0 < \beta < 1$.

If the manager chooses (I_1^A) to maximize the value of the firm, then the maximization problem is as follows :

$$(3) \quad \max \beta(1-\tau^A) K(I_1^A) + \frac{\beta^2}{1-\beta} E(I_1^A) - (I_1^A)$$

From this we get our first order condition that

$$(3') \quad K'(I_1^A) \left[\beta(1-\tau^A) + \frac{\beta^2}{1-\beta} [1-\tau^A - p(\tau_H^A - \tau^A)] \right] = 1$$

$$(4) \quad K'(I_1^A) = \frac{(1-\beta)}{\beta[1-\tau^A - \beta p(\tau_H^A - \tau^A)]}$$

This equation can be solved for (I_1^A) for given parameters and functional forms. If the first best level would be the one when there was no uncertainty about future tax rates (i.e. $p = 0$ or $p = 1$), then we can easily see that the uncertainty about future tax rates will manifest itself in investment that is no longer at first best levels.

The national firm, in the second period, chooses the optimal investment in a similar fashion. The optimal level of investment (I_2^A) is such that it is

$$(5) \quad \operatorname{argmax} \frac{\beta^2}{1-\beta} E(I_2^A) - \beta(I_2^A)$$

The first order condition for this equation is

$$(6) \quad K'(I_2^A) = \frac{(1-\beta)}{\beta[1-\tau^A - p(\tau_H^A - \tau^A)]}$$

which can be solved for I_2^A .

The rate of return on this investment is even higher than the rate of return on the previous investment indicating that investment is lower for the second investment. However, this in large part is due to the fact that this investment takes place one period after the first investment. For the second investment the risk associated the investment will seem more severe because the guaranteed first period return that the first investment receives, no longer exists.

The total expected value of a national firm (V_{NAT}) is the expected value of the first investment plus the expected value of the second investment as in (7) below.

$$(7) \quad V_{NAT} = \beta(1-\tau^A) K(I_1^A) + \frac{\beta^2}{1-\beta} [E(I_1^A) + E(I_2^A)] - (I_1^A) - \beta(I_2^A)$$

OPTION 2 : Invest initially in country A and then invest in country B (i.e. become multinational). For simplicity we will assume throughout the discussion that $\tau_H^A > \tau^B > \tau^A$. If $\tau^B < \tau^A$ then most results follow very easily, whereas if $\tau_H^A < \tau^B$ then investing in country B is not a suitable alternative.

In this case both investments must be chosen in order to maximize the value of the firm. In other words, I_1^{A*} and I_2^B are chosen to maximize V_{MNE} (expected value of the MNE).

$$(8) \quad V_{MNE} = - (I_1^{A*}) + \beta [(1-\tau^A) K(I_1^{A*}) - (I_2^B)] \\ + \frac{\beta^2}{1-\beta} [E(I_1^{A*}) + (1-\tau^B)K(I_2^B) + p(\tau_H^A - \tau^B) T_A^B + (1-p)(\tau^B - \tau^A) T_B^A]$$

where $p(\tau_H^A - \tau^B) T_A^B + (1-p)(\tau^B - \tau^A) T_B^A$ is the expected tax saving in every period after Period 1. The first order condition when we differentiate with respect to I_1^{A*} is

$$(9) \quad K'(I_1^{A*}) \left(\beta(1-\tau^A) + \frac{\beta^2}{1-\beta} [1-\tau^A - p(\tau_H^A - \tau^A) + p(\tau_H^A - \tau^B) \frac{dT_A^B}{dK^A}] \right) = 1$$

$$(9') \quad K'(I_1^{A*}) = \frac{(1-\beta)}{\beta [1-\tau^A - \beta p(\tau_H^A - \tau^A) + \beta p(\tau_H^A - \tau^B) \frac{dT_A^B}{dK^A}]}$$

The ability to transfer profits (cash flows) between the two regions allows for more investment in the home country than would have been possible had the firm been national. (Compare to (4))

Similarly the first order condition when we differentiate with respect to I_2^B is

$$(10) \quad K'(I_2^B) \frac{\beta^2}{1-\beta} [(1-\tau^B) + (1-p)(\tau^B - \tau^A) \frac{dT_B^A}{dK^B}] = \beta$$

$$(10') \quad K'(I_2^B) = \frac{(1-\beta)}{\beta [(1-\tau^B) + (1-p)(\tau^B - \tau^A) \frac{dT_B^A}{dK^B}]}$$

From the above we can note that the return from this investment is sensitive to parameter choice and may or may not dominate the second investment for a national firm. (Compare to (6) above)

An important consideration is whether domestic investors in country B will want to acquire this specific asset (I_2^B) and to determine the price they will be willing to pay for the same. Note, it is quite unlikely that a domestic investor in B would care to purchase (I_2^B); instead they will purchase some investment level I^B that maximizes

$$(11) \quad V_B(I^B) = \frac{\beta^2}{1-\beta} [(1-\tau^B)K(I^B)] - \beta C(I^B) .$$

because a purely domestic investor in B will be unable to transfer profits to foreign subsidiaries. Further, the simple fact that the MNE is able to reduce its tax payments on its investment in B (and A) will cause a firm in A to attribute more value to the investment than a domestic investor in B.⁴⁴

Quite clearly, there is a trade-off to be considered by the firm before it decides to invest abroad. On the one hand, it benefits significantly from being multinational if tax rates are raised in A above the existing level in B. On the other, it stands to lose if *ex-post* tax rates in A are unchanged, because B then is a relatively high tax region. However, this loss is offset marginally by the ability of the firm to shift profits from B to A and thereby reduce the tax liability of the foreign operation. In the next section we briefly demonstrate the conditions under which being multinational is preferable to being national and bring this trade-off to light.

⁴⁴ Refer to Appendix II for a more detailed proof.

Section IV

In order to get a better feel for the workings of this model and the conditions under which being a MNE is advantageous, a few simulations were run on the various parameters. The following functional forms were used in the analysis:

$$\text{Discount Factor : } \beta = \frac{1}{1+r}$$

Assume that $r = 10\%$

$$\text{Pre-tax Profits : } K(I) = 30I - I^2$$

($K' \geq 0$ for $I \leq 15$; $K'' < 0$ for every I)

$$\text{Sunk Cost of Investment : } C(I) = I$$

$$\text{Profits transferred from country A to country B : } T_A^B = \gamma K(I^A);$$

$$\text{Profits transferred from country B to country A : } T_B^A = \gamma K(I^B)$$

where $0 \leq \gamma \leq 1$. γ = percent of profits transferred.

p = probability that tax rates in A will be raised to τ_H^A from τ^A .

Comparison between Multinational (MNE) and National (NAT) Enterprises

Key Variables : Expected Value of the Firm and Investment Levels

(subdivided into Total Investment, Initial Investment and Follow-up Investment).

Initial investment at home for the MNE is always greater than or equal to the amount invested by the national firm in period 1 (from equations 4 and 9'). The comparison between the foreign investment for the MNE and the second investment of the NAT is sensitive to the parameter values. (Refer to Table 1)

Table 1

	P	γ	r^A	t_{II}^A	r^B	$V_{MNE} > V_{NAT}$	Total Inv. (MNE) > Total Inv. (NAT)	Foreign Inv. (MNE) > Second Inv. (NAT)	Firm Diversification > Investor Level Diversification
(1)	0.4	10%	34%	46%	40%	No	No	No	Yes
(2)	0.45	10%	34%	46%	40%	Yes	No	No	Yes
(3)	0.5	10%	34%	46%	40%	Yes	Yes	Yes	Yes
	<u>Varying</u>	<u>p when γ</u>	<u>$\approx 10\%$</u>						
(4)	0.35	30%	34%	46%	40%	Yes	No	No	Yes
(5)	0.4	30%	34%	46%	40%	Yes	Yes	No	Yes
(6)	0.45	30%	34%	46%	40%	Yes	Yes	Yes	Yes
	<u>Varying</u>	<u>p when γ</u>	<u>$\approx 30\%$</u>						
(7)	0.4	10%	38%	42%	40%	No	No	No	Yes
(8)	0.45	10%	38%	42%	40%	No	No	No	Yes
(9)	0.5	10%	38%	42%	40%	Yes	Yes	Yes	Yes
	<u>Varying</u>	<u>p when γ</u>	<u>$t_{II}^A - r^A$ is small</u>						

The key conclusions we can derive from the model are that :

- Higher the probability that the tax rate is raised, it is better to be a MNE (rows 1-3).
- Higher the percentage of profits that can be transferred to a low tax region, the greater the benefit to being multinational (rows 4-6).
- If the tax rates in A are expected to stay within a narrow range, then you need a higher probability that taxes will be raised before becoming MNE (rows 7-9).
- Initial Investment for MNEs is greater than Initial Investment for national firms implying that MNEs are protected from adverse tax rate changes.
- Firms may invest in relatively high tax locations in anticipation of possible tax rate changes at home (rows 2-6).
- It may be optimal to invest abroad even if the expected tax rates in the home country are lower than the tax rate in the foreign country (row 2).
- Value assigned by an MNE to an investment in B exceeds that assigned by a domestic investor in B.⁴⁵
- Diversification by the MNE is more valuable than investor-level diversification.

The most interesting conclusion of those listed above is the result that a firm may choose to invest abroad even if expected tax rates in the home country are lower than the tax rate in the foreign country. This result follows because the firm is not comparing after-tax rates of return, but instead the contribution of each investment opportunity to total firm value. A comparison of expected after-tax rates of return may ignore the tax saving that a foreign investment opportunity provides, and hence is incorrect.

To recapitulate the findings in this section, the greater the ability to shift profits, the higher the probability that tax rates will be raised, lower the marginal tax rate in B and wider the spread between possible future tax rates in A, the greater the benefit to being MNE. Further, we are able to provide an

⁴⁵ Based on simulations performed that are not reported here.

additional justification for the existence of a MNE because investors will be worse-off if they try to replicate the diversification benefits provided by the MNE by buying shares in a replicating/exact set of purely national organizations.

Section V

Possible Extensions

As is evident from the model assumptions, this approach may border on being simplistic because it ignores a number of key aspects of doing business in an international context. However, the insights provided are significant as the model demonstrates how tax regime volatility creates a situation where foreign investment may be preferred to domestic investment, and if this is the case it also results in more investment at home by the MNE when compared to its national counterpart.

This model could be extended in a number of ways if we relax some of the assumptions. First, we assumed that there was no additional cost to being multinational. This may not be an appropriate assumption, but as long as the cost of acquiring the option to lower tax payments in the future is less than the expected increase in value from being multinational, firms will prefer to invest abroad. An interesting issue is whether the parent organization will be willing to incur the costs to set up a subsidiary as opposed to a sales branch to gain financial flexibility. If we include the additional cost of operating a subsidiary into our model we may be provided with a way out of the degenerate result that all firms should be multinational, especially if this cost is high for some firms (generally small firms) and less significant for other firms.⁴⁶

Second, the model assumes that all uncertainty about future tax rates in country A is resolved after period 2. This would suggest that firms may be better off postponing the investment until period 3, as long as the opportunity cost of doing so is not too high. The model could be modified to incorporate tax volatility in future periods, but the basic results provided here will still hold. We also assumed that tax rates in country B were static and not subject to any policy changes. Once again, this assumption was made to make the model more tractable and could be relaxed without changing the results significantly.⁴⁷

⁴⁶ Since we assume perfect competition in all real markets and asymmetries in only tax regimes, all firms have an incentive to be multinational if they can exploit the asymmetries.

⁴⁷ Refer to Muralidhar (1991b).

Third, we assumed that the returns from investing locally and abroad were equal. If we are to incorporate the other theories of FDI into our analysis, then this is clearly not the case. As indicated in Section III, the model could be modified to incorporate the imperfections in the real markets. In this situation, other firms will not be able to acquire this asset because they will always be outbid. However, the tax-saving hypothesis for the single firm under consideration will still hold. Moreover, unless the cash flows from servicing a foreign market through exports greatly exceed the cash flows from servicing that market through a foreign operation, the results from the model will still hold.

Fourth, we have ignored tariffs, transportation costs and exchange rates completely in this model. There is some discussion in the popular literature about how firms invest abroad so as to evade tariff-induced barriers to trade. Once again, a market imperfection provides a sufficient condition for a firm becoming multinational. In the case of tariffs the foreign market is threatened and hence the firm invests in the foreign country (also referred to as "tariff-jumping") to protect its market.

Fifth, some countries either have tax information sharing agreements or are considering implementing such arrangements; for example, the US and the UK are presently considering a tax information sharing agreement. Should this materialize, firms doing business in these two countries will find that the benefits derived from their international financial networks will be negated to some extent. This also raises another issue that was addressed rather meekly by the model. The only constraint that we placed on the transfer of pre-tax profits was that an exogenous fraction (γ) of realized profits were shifted from the high tax region to the low tax region. We could have introduced some kind of monitoring by the IRS and this might have the effect of increasing the expected cost of profit-shifting activity. In such a situation γ should be determined endogenously and would be dependent on how aggressive the IRS was in monitoring the firm's behavior.⁴⁸

⁴⁸ We will attempt to address this in another paper.

Finally, we could argue that if firms could bargain with host countries over corporate tax rates, then given that tax rates are endogenously determined, becoming multinational will increase the bargaining power of a single firm. This notion of increased bargaining power with governments could be demonstrated through modifications to the model.⁴⁹ Once we establish such a model we can also use it to show how multinationals can gain increased bargaining power with labor in different countries and also with governments over treatment in the non-tax aspects of doing business.

The model provides interesting insight into how organizations may react to and benefit from dynamic and less than perfectly correlated tax regimes. A number of simplifying assumptions were made so that the level of exposition was not too technical, but as indicated above, these did not detract from the validity of the model. In addition, this model, with some variations, could be used to discuss bargaining power of MNEs with agencies in different countries.

⁴⁹ In this paper we assumed that tax rates were exogenously determined.

Section VI

Key Observations and Policy Considerations

While executives in MNEs may not be candid about admitting that they move profits between different countries,⁵⁰ most officials who work in this area of the IRS are convinced that "abuses" by MNEs are rampant.⁵¹ A recent Business International survey⁵² shows that the key factors that drive inter company pricing policies are : ensuring an arms' length relationship, avoiding problems from tax authorities, minimizing worldwide taxes and maximizing profits. Furthermore, the previous analysis shows that these actions, though bordering on illegality, could be rational and perfectly consistent with firm-value-maximizing behavior.

By creating a production facility in a country with an independent tax regime, the firm gains the maximum number of channels through which it can move profits within the MNE as demonstrated by Figure 1. Also, foreign investors can use the synergies that a new investment generates to justify investment that domestic investors in the foreign country might find unprofitable.

For both host and home countries, the policy issues are interesting. A firm that is multinational reveals itself to be one that could take advantage of its international financial network. However, the question of interest is : Should a home country be concerned whether a MNE is hiding profits or not? A country with a territorial system of taxation will be concerned if it is a relatively high tax region as demonstrated by the model. This will also be true if the home country pursues a residency-based system.

While all profits must ultimately be remitted back to the parent company, the home country will receive its tax revenue, though after a considerable delay if

⁵⁰ Bradley (1991) states that, "[w]hile many companies argue that the minimization of tax is not an overriding concern, many appear to have structured their transfer prices and to have implemented policies expressly designed to take advantage of tax differences between countries." (See 29•18)

⁵¹ Duke (1991) - Wall Street Journal. Also refer to Delmar (1991) in International Business. Scholes and Wolfson, Ch. 14 , lists some of the MNEs that the IRS has investigated for tax-evasion.

⁵² See Business International (1991).

it is a high tax region under a residency based system. More important, by offering foreign tax credits (FTCs) for taxes paid to a foreign country, the home country may lose because its final take may be greatly reduced. Earnings that would normally be generated in the home country will be generated abroad and FTCs will be offered for taxes paid on those profits. This would indicate that home countries may also have an incentive either to lower tax rates or else to monitor the behavior of MNEs if they are high tax countries.⁵³

MNEs may operate subsidiaries by either giving them the autonomy to achieve the local optimum or else ensure that they are made an integral part of the global operation. Given these two possibilities, a host country can never be sure whether the MNE is attempting to maximize a local or a global optimum. The implication for host countries is that they should also lower marginal tax rates or else monitor the actions of subsidiaries.

The policy implications for home and host countries suggest that all countries may be inclined to compete over taxes to encourage investment and prevent profit-shifting away from their tax jurisdiction.⁵⁴ Another view is that of Vernon (1972) who argues that "[a] multinational approach to tax problems could take several different forms. A relatively easy response would be to enunciate some general principles applicable to all tax jurisdictions.....If the principles were adopted by a sufficient number of countries, they would accomplish two things: they would reduce the chances that a multinational enterprise, caught between the scissor blades of two taxing jurisdictions, would be unfairly taxed; at the same time, they would increase the assurances that such enterprises were not using their flexibility to slip between the national taxing authorities. Still another approach would be fundamental in character and more ambitious in reach. In view of the arbitrary nature of profits assigned to subsidiaries, it can be argued that the assessment of tax liability in any jurisdiction should be based on the proration of the

⁵³ Tax isn't the only issue of interest for the home country. Other issues that concern governments include development of regions, employment etc. Therefore, if reductions in tax rates lead to more investment and higher reported profits, governments may benefit through more than one avenue.

⁵⁴ Giovannini (1989) discusses the need for European governments to coordinate tax policy rather than compete over tax rates.

consolidated profit of the multinational enterprise as a whole, according to an agreed proration formula."⁵⁵

Governments have even considered working together to prevent the MNEs from benefiting from asymmetries in tax regimes. For example, in an attempt to curb abuses, the UK. had offered to share tax information with the US after the US threatened to retaliate against foreign-owned subsidiaries suspected of shifting profits. Such a move would make the international financial network less useful in manipulating the transfer of funds between countries. As Lessard (1979) notes, it seems quite natural that if internal financial transfers are unconstrained then tax factors can magnify the distribution of tax revenues. "It is precisely in such a world where countries would retaliate quickly against any competitive tax change, and the only stable solution would be a common system."⁵⁶⁵⁷

⁵⁵ Vernon (1972), pg 157.

⁵⁶ Lessard (1979).

⁵⁷ Recent working papers that address policy issues related to tax evasion include Hines (1990), Levinsohn and Slemrod (1990), Slemrod (1990) and Sinn(1990).

Conclusion

From the above discussion we can conclude that if corporate tax rates are variable and less than perfectly correlated; external markets for the trading of tax shields are incomplete; and MNEs can internalize tax management, we are provided with the necessary and sufficient conditions for a firm with international business to invest abroad, and an additional justification for the existence of a MNE. A firm is more likely to invest abroad than in the home country, and internalize tax management, if there is a reasonable probability that tax rates will be raised above the tax rate of a foreign country that is not expected to change. The benefit to being able to shift profits creates a situation where it may even be suitable to invest today in a relatively high tax environment. By investing abroad, the firm acquires a portfolio of options that protects the MNE from adverse policy changes in every period, and the acquisition of the options allows the firm to invest optimally and maximize expected firm value. Finally, if investing abroad is an *ex-ante* response, rather than an *ex-post* reaction to possible changes in the domestic tax rate, then, when tax rates change, we will witness profit-shifting within the multinational, and not necessarily increases in capital flows to the country with the higher after-tax rate of return.

Appendix I

Abbreviated Review of the Theories of FDI

The most traditional view (*Iversen - 1935*⁵⁸) was that there was a higher rate of return to be earned from foreign investments that encouraged domestic investors to consider investment opportunities abroad. However, this theory suffered at the hands of critics because it could not explain why FDI was preferred to a purely financial investment and further could not adequately explain why cross-border (i.e. US firms investing in Europe while European firms are simultaneously investing in the US) and/or intra-industry FDI might be an acceptable phenomenon. In addition, this approach clearly fails to explain why transactions must be internalized by the investing firm.

There are a number of theories that identify imperfections in product and/or factor market as being a necessary condition for FDI and we briefly review some of them. *Krause and Dam (1964)*⁵⁹ emphasize that inputs could be cheaper in foreign countries causing firms to invest abroad. This approach explains why production will take place abroad, but does not clearly explain why foreign investors will outbid domestic investors for the acquisition of an asset.

A slightly different approach puts emphasis on the MNE (Multinational Enterprise used interchangeably with MNC or Multinational Corporation) as a vehicle through which imperfections in markets for goods or factors can be overcome.

-The *Hymer-Kindleberger* hypothesis argues that imperfections in the factor and/or output markets, or interference by firms or governments separates markets. Certain internally transferable advantages, like knowledge, make FDI the preferred alternative to exports or licensing because through FDI the MNE is able to capture the most rents. Exports may cause the firm to incur transportation costs and also be exposed to tariffs, while licensing may not allow the firm to fully control the activities of the licensee and hence the firm might not be able to fully capture the rents that accrue.

⁵⁸ Citation - Dunning (1988).

⁵⁹ Citation - Rugman (1979).

- *Caves* (1971)⁶⁰ has proposed that subsidiaries are essentially replicas of the parent company and as there are economies in horizontal integration, firms choose to exploit these economies by becoming multinational.

- *Johnson* (1970)⁶¹ suggests that the firm internalizes services that are of a public good nature, like new production, marketing or management techniques. This makes operating a subsidiary a low cost venture whereas a domestic investor must acquire these skills and hence the foreign firm makes the investment.

- *Buckley and Casson* (1985) propose that actions of firms can replace the market or else augment it. A cost-benefit analysis that is undertaken must show internalization to be the best alternative for a firm to create a subsidiary in a foreign country. It is suggested that the subsidiary lowers transactions cost for the parent because of the nature of the product or industry. The MNE is a vehicle through which mobile resources are transferred, at least cost, to areas with complementary immobile inputs through the internalization of transactions (see also *Dunning* below); however, the approach of *Buckley and Casson* is not distinctly distinguishable from that of *Hymer and Kindleberger*. *Dunning* (1975) argues that while location may be diversified, ownership need not be, and hence a multinational could take advantage of the benefits of internalizing transactions.

While these theories clearly highlight the importance of being multinational when there are imperfections in the factor or product markets, *Dunning* (1988) states that the industrial organization approach of *Hymer and Kindleberger* is not clear on where the Ownership Advantages are exploited. *Johnson and Caves* attempt to provide explanations for Ownership Advantages, but are not specific on the possible Locational Advantages of different countries.⁶² This is not to say that their contributions were not significant; instead, they identified many key issues and provided a basis from which later theories would evolve.

One of the more popular strands of the FDI literature is that of *Vernon* (1971, 1977) and the economists that continued his school of thought (*Wells* (1972)).

⁶⁰ Citation - *Buckley and Casson* (1985).

⁶¹ *Ibid.*

⁶² For a more detailed evaluation of these theories refer to *Dunning* (1988), Chapter 1.

The famous *Product Cycle Model* states that products undergo predictable changes in production and marketing. As products travel through a familiar cycle of innovation, growth, maturation and senescence, production is determined by the economies of scale in local and foreign locations. The firm continues to export until a foreign market is threatened or producing abroad becomes a low cost alternative, especially when the ties to immobile factors in the home country get weaker. This approach was extremely useful in explaining US investment abroad and fits the OLI paradigm well, but failed to provide an adequate explanation for cross-country FDI. An important contribution of this approach is the emphasis on providing a time-line for when foreign investment will take place.

Knickerbocker(1973) uses the product cycle model as a basis to suggest that a majority of firms invest abroad for defensive purposes and proposes that oligopolistic reaction in large part explains capital flows. Members of an oligopoly feel that a foreign market is threatened when one competitor invests abroad, causing all the other members of the oligopoly to react in an identical fashion and follow suit. Essentially, domestic oligopolies ultimately cross borders to establish a global oligopoly. "Oligopolistic reaction", as an explanation for foreign investment, is credible and has gained wide acceptance.

In the financial variety, two key theories present themselves for discussion:

- *Aliber* (1970) suggests that MNEs have an advantage over national firms in international financial markets. Investors are assumed to be myopic and apparently treat all assets of an MNE as if they were in the same currency-area as the parent. This is supposed to lower the risk premium lenders require from MNEs, because the firm no longer has to compensate the lender for any expected depreciation in currencies, and in turn lowers the borrowing costs for the MNEs. The shortcomings of this approach are obvious as investors are not consistently myopic over the long term and there is no obvious reason why transactions must be internalized.

-*Rugman's* (1979) diversification of earnings theory suggests that the value of a firm is dependent on the flows its assets generate as well as the variance in those flows. The firm, by diversifying earnings sources, especially between

countries where the coefficient of correlation of earnings streams is less than one, is able to ensure that the profits are more stable and hence the value of the firm is enhanced. Rugman argues that while theories of market imperfections are important, a theory that enunciates the reduction of risk of profit through diversification is significant, but unless the multinational firm is a superior contracting medium, or faces fewer barriers than those faced by portfolio investors, firm level diversification might not be worthwhile.⁶³

A more recent contribution ties exchange rate movements to informational imperfections in capital markets.

- *Froot and Stein* (1989) state that a depreciation in local currency systematically lowers relative wealth and can lead to domestic assets being acquired by foreign agents who can make higher bids for the same asset. However, by their own admission, this theory cannot explain greenfield investment and outward flows of investment during a currency depreciation. Once again, this theory cannot explain why transactions need to be internalized, but instead explains why foreigners might be able to acquire a domestic asset at a particular point in time. We summarize the above discussion in Table 2 below.

Table 2

Theory	Ownership Advantages	Location Advantages	Internalization Advantages
1) Traditional - Iversen	Yes	Yes	No
2) Krause and Dam	No	Yes	No
3) Hymer-Kindleberger	Yes (weakly)	Yes	Yes
4) Vernon - Product Cycle	Yes	Yes	Yes
5) Knickerbocker	Yes	Yes	Yes
6) Buckley and Casson/Dunning	Yes	Yes	Yes
7) Johnson/Caves	Yes	Weakly	Yes
8) Aliber	Yes	Yes	No
9) Rugman	Yes	Yes	No
10) Froot and Stein	Yes	Yes	No

⁶³ Unpublished memo from Prof. Lessard.

Appendix II

Proof of why domestic investors in B will not be able to purchase the asset

The expected value of the investment (I_2^B) to a firm in country A: $V_{MNE}(I_2^B) = V_{MNE} - V(I_1^A)$, where $V_{MNE} = V(I_1^{A*} + I_2^B)$. The reason the second term is $V(I_1^A)$ and not $V(I_1^{A*})$ is because I_1^A is all the firm will invest if the management was planning to create a national firm. However, when the firm invests in country B, the optimal investment in A is now I_1^{A*} . Hence, $V(I_1^{A*}) - V(I_1^A)$ is the incremental increase in expected firm value only if the firm invests in country B. This incremental value must therefore be attributed to the value of the foreign investment.

$$\begin{aligned}
 (12) \quad V_{MNE}(I_2^B) &= V(I_1^{A*} + I_2^B) - V(I_1^A) \\
 (13) \quad &= -C(I_1^{A*}) + \beta((1-\tau^A)K(I_1^{A*}) - C(I_2^B)) \\
 &\quad + \frac{\beta^2}{1-\beta} \left[g((1-\tau_H^A)K(I_1^{A*}) + (1-\tau^B)K(I_2^B) + (\tau_H^A - \tau^B)T_A^B) + \right. \\
 &\quad \left. (1-g)((1-\tau^A)K(I_1^{A*}) + (1-\tau^B)K(I_2^B) + (\tau^B - \tau^A)T_B^A) \right] \\
 &\quad - \left(\beta(1-\tau^A)K(I_1^A) + \frac{\beta^2}{1-\beta} \left[g(1-\tau_H^A)K(I_1^A) + (1-g)(1-\tau^A)K(I_1^A) \right] - C(I_1^A) \right)
 \end{aligned}$$

The value of the same investment to an investor in B is (11). This implies that the MNE can outbid the domestic investor in B to the tune of $V_{MNE}(I_2^B) - V_B(I_2^B)$, which is generally greater than zero.⁶⁴

⁶⁴ This statement is based on simulations we performed using the model in Section IV.

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Introduction to Part II

It has been argued that uncertainty about demand, factor costs and tax rates in local environments will affect the investment decisions of uninational firms, when investment is irreversible. However, these arguments have not considered the impact of volatility of local environments on MNEs. The next two papers demonstrate that having operations in more than one country provide MNEs with flexibility, and how static NPV analyses may not capture the value of flexibility. We argue that the value of a foreign project = NPV of the foreign project assuming that it was a stand-alone project + value of financial and real flexibility that the project provides the parent organization (where we define financial flexibility to be the ability to shift profits to favorable tax locations when tax regimes are changing and real flexibility to be the ability to switch capacity utilization to the lowest cost location when domestic costs and exchange rates are volatile).¹

We introduce options pricing models to value flexibility since having flexibility is tantamount to holding a portfolio of options and offer an adjusted NPV calculation that incorporates this portfolio of options into the investment decision. A MNE is shown to invest in certain projects that it would have originally rejected, once management accounts for the value of flexibility, because the options that it has acquired from investing in more than one location provide the MNE with protection from adverse cost shocks.

While ideally both real and financial flexibility should be valued simultaneously, we separate the analysis for simplicity. In Chapter II we value financial flexibility and in Chapter III we value a specific form of operational flexibility where the multinational firm has global demand that has to be met by factories in diversified production locations. An interesting alternative to this model would be a two country model, where the MNE has demand in both countries and has to decide between producing in one location, maintaining dedicated plants in the two

¹ There are other factors that might cause NPV analyses to be less than optimal. For example, if a project is being undertaken to hold a competitor hostage in its home market, a negative NPV project may still be accepted.

countries or else maintaining plants in the two countries, but shifting capacity utilization to take advantage of excess capacity in the lowest cost location.

Each of these papers is tested with tax rate and wage data, and we show how investment location and capacity choice decisions are impacted.² While these simulations are a first approximation of the true value of flexibility, they provide a benchmark for the potential value of real and financial flexibility of MNEs. The key idea underlying these papers is that, within a MNE's business environment, the degree of correlation of various business environments across countries may be of greater concern than the volatility of these same business environments (considered in isolation) in the individual countries.

² When factor costs are volatile, investment timing will also be affected and we explore this in the Appendix to Chapter III.

CHAPTER 2

"Valuing the Financial Flexibility of a Multinational Enterprise : An Options Pricing Approach"

Abstract

We argue that when corporate tax obligations are variable, a multinational firm has financial flexibility (the option to shift profits to favorable tax regions in every period and lower the global tax liability), and that traditional NPV analyses of foreign projects may not capture the value of this flexibility. We introduce an options pricing model to value the flexibility that internalizing tax management provides, and offer an adjusted NPV calculation that incorporates this portfolio of options into the investment decision. While national firms may find certain projects unattractive, a multinational firm is shown to acquire projects once they value the flexibility. We use corporate tax rate data to compare potential projects in different countries for a US-based MNE. The paper concludes by discussing the implications of these results for MNEs and governments.

"The hope of evading such taxes by smuggling gives frequent occasion to forfeitures and other penalties which entirely ruin the smuggler; a person who no doubt highly blamable for violating the laws of his country, is frequently incapable of violating those of natural justice, and would have been, in every respect, an excellent citizen, had not the laws of his country made that a crime which nature never meant to be so."

Adam Smith, 1776

Introduction

The financial system of the multinational enterprise (MNE) has, for a number of years, attracted the attention of academicians, corporate treasurers and accountants, and government officials. The source of this attention has been the controversy that has been generated by different tax systems around the world, and the multinational enterprise's reaction to these different tax regimes. There are numerous transactions that are conducted between the parent company and a subsidiary or between subsidiaries. A multinational enterprise (MNE) can take advantage of the asymmetries that exist between tax policies in different countries, and can design transactions so as to reduce its global tax liability. For most governments, the issue is whether tax-saving is synonymous with tax-evasion, and if so, how severe the government should be in policing the actions of MNEs. A recent article provides examples of how US-based MNEs have reduced their tax liability in the past, and how the Sundstrand Corporation and Bausch and Lomb are paying the price of being audited by the Internal Revenue Service.¹

This situation has created a rich agenda for the research community.² On a macro level, numerous studies have been conducted to determine the effect of tax rate changes on international capital flows, allocation of real activities and/or tax revenues. The general notion is that a lowering of the corporate tax rate in a country raises the after-tax rate of return relative to other countries, in turn attracting foreign capital. However, the results of these

¹ John Delmar, "The Tax Man Cometh," International Business, December 1991.

² See Caves (1982) for an excellent review.

studies do not provide a consensus on whether tax rate changes stimulate capital flows.³

On the micro level the questions have been more widespread, and the research has been both predictive and empirical. Horst (1971) demonstrates how an MNE, through an appropriate selection of transfer prices, should maximize the value of a two-country firm in the presence of tariffs and taxes. This work has been complemented by empirical research that seems to indicate that MNEs resort to profit shifting and attempt to lower their global tax liability (Horst 1976, 1977; Hines 1990; Hines and Rice 1990; Harris et al. 1991). Lessard (1979) reviews the literature on taxes and MNEs and examines the extent to which real investment and production decisions are affected by the MNE's ability to transfer profits from high tax jurisdictions to tax havens. The review reveals that existing research did not show conclusively how real configuration decisions would be impacted by profit shifting opportunities.

Muralidhar (1991a) provides a predictive model that addresses the questions that Lessard (1979) sought to examine. The paper provides an explanation for foreign direct investment (or the existence of a MNE) that is dependent on the ability of MNEs to arbitrage tax rates around the world. Muralidhar (1991a) is able to show that if tax regimes around the world are changing and less than perfectly correlated, and multinational firms can shift a small fraction of profits between locations, expected firm value is maximized by investing abroad rather than at home, and diversification by MNEs dominates investor-level diversification. Such a strong result follows because there is an incomplete external market for trading tax shields and hence the MNE gains a comparative advantage by internalizing tax management.

This paper attempts to fill a void left by existing research. While it is generally accepted that MNEs can reduce their global tax liability, and that

³ Refer to Hartman (1981, 1984, 1985), Boskin and Gale (1987), Young (1988), Slemrod (1990), Jun (1990) and Scholes and Wolfson (1990). Further, Giovannini (1989) provides a fascinating discussion of the numerous loopholes in tax policy in Europe that allow firms to either lower their tax payments or else defer taxes to some later date, and the need for coordination of European tax policy.

MNEs have financial flexibility, no attempt has been made to determine the value of maintaining a presence in more than one tax jurisdiction, and how a valuation of financial flexibility might affect strategic decision-making. We approach the problem from the perspective of a manager in the corporate treasury department (and/or strategic planning) of a national firm that is considering multinationality, and present a stylized and rigorous method to value the ability of a MNE to internalize tax management.

The textbook approach to evaluating a foreign project would involve calculating the net present value (NPV) of a project's projected after-tax cash flows⁴ after accounting for foreign exchange issues. It has also been suggested that differences in economic and political environments be incorporated into the NPV analysis.⁵ However, these calculations, unless properly done, ignore the fact that the foreign project now allows the firm to move profits between locations - an opportunity it would not have been afforded if it had continued to invest at home. We know that this flexibility is valuable, especially when tax rates around the world are not static or when exchange rate fluctuations affect the taxable status of international business units and when the external market for trading tax shields is non-existent or incomplete. We provide a methodology to value financial flexibility, since traditional NPV rules may not capture the unique relationships that foreign investments have with existing investments.

We show how options pricing models can be used to value financial flexibility and how this valuation should be used in conjunction with simple NPV calculations to determine the value of investing in more than one country. While volatility in domestic tax regimes can affect the value of projects, we specifically show how co-variation between tax regimes in the host and home country adds value to a project.

Other things equal, we demonstrate how marginal projects may be accepted by foreign investors (and rejected by domestic investors because of a negative NPV) once the value of financial flexibility is included. In addition, we

⁴ Refer to Brealey and Myers (2nd edition) Chapter 6. See also Chapter 32, Section 4 for a discussion of international investment decisions.

⁵ Refer to Lessard (1978) and Lessard and Shapiro (1983).

perform simple comparisons across some developed countries and can conclude that, for US-based MNEs, the value of financial flexibility as a percentage of corrected project value is more significant for projects located in Italy, Germany, Japan or Australia, than it is for projects in the UK or Canada. Further, we get a seemingly counter-intuitive result that a firm based in the US might find an investment in Italy (high-tax location) to be preferred to an investment in Canada (lower tax location) when pre-tax cash flows are the same in the two countries.

Section I provides some background information on tax issues and MNEs and introduces the new approach by arguing that flexibility, in the face of future uncertainty, is essentially an option and should be valued as such. In Section II we lay out a model to value financial flexibility. Section III contains the result of sensitivity analyses, and the comparison across developed countries, using the corporate tax rate data of those countries. Section IV suggests some extensions to this approach and Section V posits policy implications and concludes.

Section I

There are two major systems of taxation : residential and territorial. Countries that follow the residential system of taxation tax the MNE for global profits earned, but provide tax credits for foreign taxes paid. Under the territorial system of taxation, countries assess their taxes on the MNE only on local profits earned, and leave the taxation of foreign profits to foreign governments. While it may seem as if the global tax liability can be reduced only if the system of taxation is territorial, tax-saving is possible even if the system of taxation is residential.⁶

MNEs possess the advantage in dealing with tax authorities because there is an asymmetry of information between what they know and what tax authorities around the world know about the geographical distribution of profits. This has led to the frequent accusation that MNEs abuse this informational advantage to reduce the tax take of the countries in which it does business.⁷

MNEs have at their disposal a number of ways of lowering their global tax liability, some of them legal and some that border on illegality. On the one hand, they can shift production activity to favorable tax locations and generate a larger share of global profits in the relatively low tax environment. However, this method is most effective when management of the MNE uses many plants around the world to service a global market for the products produced. Shifting production (in turn, profit generation) may not be profitable or feasible if the various subsidiaries of the MNE are catering to local or regional markets.

The point of contention between tax authorities and MNEs has focused not on the shifting of profits through shifting production activity, but on shifting

⁶ The U.S. follows a residential system of taxation. U.S.-based MNEs have been known to exploit tax havens to lower their effective tax rate below 34%. Moreover, these MNEs attempt to defer taxes due on foreign-earned profits when the foreign tax rate is below that of the U.S. Presently however, the US is effectively following a territorial treatment of foreign source income because of the relatively low tax rate in the US.

⁷ Given the complexity of the multinational enterprise, there is some uncertainty about what the "true" profitability of any one operation is. However, management is always in a position to decide whether or not to move locally generated profits to favorable tax locations.

of profits through financial management. Effective financial management implies that the corporate treasurer in the parent company can select the optimal channel and/or the timing of transactions so as to move profits to the location of choice.⁸ Examples of such financial transactions include the selection of optimal transfer prices on intra-company goods flows, and optimal royalty, interest and dividend repatriation schedules to take in favorable tax treatment in any one country. In addition to moving profits from high tax to low tax environments, MNEs can move profits from subsidiaries that are in a tax paying position to others that are showing tax losses. While the firm is constrained from changing the terms of intra-company transactions periodically and from transferring all global profits to the most favorable tax location by the laws laid down by the regulatory bodies in the different countries, some tax saving is possible in every period through profit-shifting.⁹

For the purpose of this paper we ignore the legality/illegality of the issues and focus instead on how a manager in corporate treasury can go about valuing the flexibility that the financial system of the MNE provides. MNEs operate in a dynamic environment where business conditions are changing constantly. The two prospects that concern us in this paper are the possibility that tax regimes¹⁰ in countries are subject to change, and that unanticipated exchange rate changes can affect the taxable status of the subsidiaries of the MNE. In this environment, having access to the multinational financial system adds value to an organization. If acquiring a subsidiary in a foreign country allows a firm to coordinate its tax reporting and save on its future tax payments, a valuation of the foreign project must include the expected present value of all future tax-savings on profits earned either at home or abroad.

⁸ Refer to Lessard (1979) for a more detailed description of the multinational financial system.

⁹ Refer to Bodner (1991), Bradley (1991) and Scholes and Wolfson, Chaps. 13 and 14 for a discussion of a host of issues pertaining to international taxation and the MNE's ability to lower its global tax liability. Refer to Appendix I for examples of profit shifting that need not involve changing transfer prices.

¹⁰ By tax regimes we mean the entire gamut of tax rules that apply to corporations that ultimately affect the effective marginal tax rate. Therefore, this definition encompasses changes in marginal corporate tax rates, depreciation allowances, investment tax credits, dividend repatriation rules etc.

If tax regimes around the world were static, then valuing financial flexibility would be extremely easy as all multinational firms will shift profits to the country identified as being the lowest tax region, in every period. When tax regimes are changing and less than perfectly correlated, the firm will still try to shift funds to the lowest tax area, but now no one country will consistently maintain that status. For example, prior to the Tax Reform Act of 1986 the US would not have been considered a tax haven, but since 1986 the corporate tax rate in the US is lower than that in many other developed countries.¹¹

The problem as we model it is very simple. We assume a two-country world (countries A and B) where the system of taxation is territorial and the tax rates are subject to change in every period.¹² The firm has one investment in country A and has to decide whether to invest in country A or country B. If the firm invests in country B then the CFO (Chief Financial Officer), in every period, observes global profits and the tax rates in the two countries and has to decide whether to move profits from country A to country B or vice-versa. Therefore, the tax-saving in every period is equal to the pre-tax profits that are shifted multiplied by the tax rate differential between the high tax rate and the low tax rate.

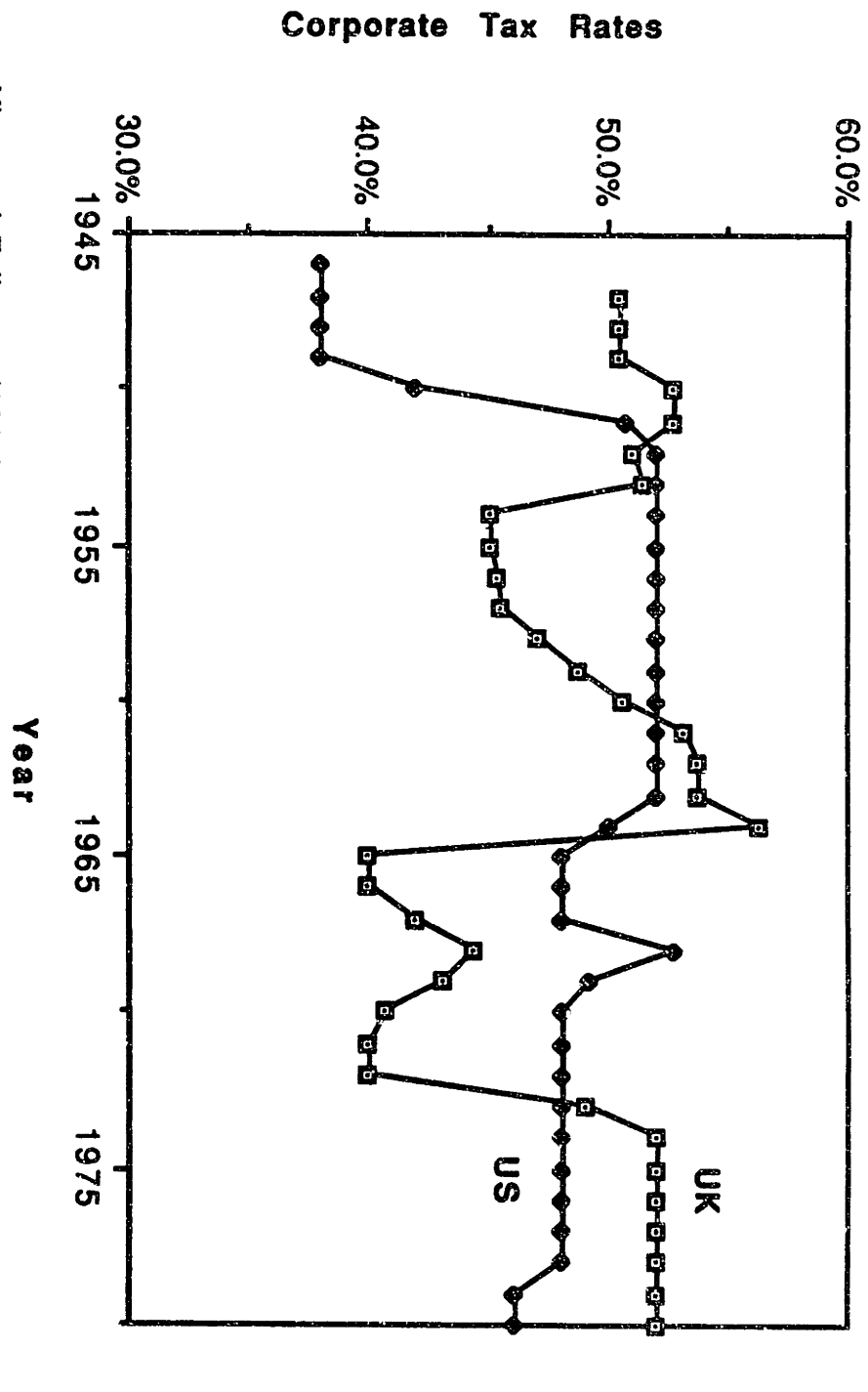
The essence of this paper is that flexibility is essentially an option. Since traditional NPV analyses may not capture the benefit that the foreign investment provides, we show how a firm could value financial flexibility by using simple options pricing models. The firm acquires a portfolio of "put" and "call" options that allows management to decide where to declare a bulk of its global profits only when it invests abroad. Hence a valuation of a foreign investment opportunity must incorporate the value of this portfolio of options that allows the firm to lower future tax payments. The total value

¹¹ In the Appendix we present tax rate data for some developed countries for 1984-1990, and comparisons between the U.S. and other developed countries validate this claim. In Graph 1 we plot the corporate tax rate in the US and the UK between 1947 and 1980. Data for this graph is in the Appendix (Source : King and Fullerton (1984)).

¹² Alternatively, we could model the scenario where exchange rate fluctuations affect the taxable status of the sub-units of the MNE and where the goal of the firm is to move profits in response to these changes in exchange rates.

Graph 1 - Corporate Tax Rates in the US and UK

(1947 - 1980)



Source : King and Fullerton (1984)

of all these options, if priced correctly, is the expected present value of all future tax-saving.

The interesting issues relating to American options on stocks are: What is the price of a given option and when is the optimal date to exercise that option? In order to value options on stocks, the assumption is made that stock price movements over time can be captured by a stochastic process. For the model of financial flexibility we can ask similar questions, but our interest lies only in valuing the portfolio of options. As we will show below, the optimal exercise rule in every period is very simple, because the firm acquires options that are European options.¹³

We model the path of the difference between tax-rates over time as a stochastic process. The objective of management is to maximize the value of the firm i.e. maximize the discounted future global after-tax profits/cash flows. Given the goal of the firm, we can demonstrate the optimal exercise rule with a simple example. If the tax rate in A is higher than the tax rate in B the firm should exercise the option to move profits from A to B, and not exercise the option to move profits from B to A.¹⁴ With this exercise rule in mind, and given the time path of tax-rates, we can derive a numerical value for financial flexibility, by determining the value of all the (European) options the firm acquires when it invest in B.

This discussion leads us to the conclusion that the value of a foreign project is the NPV of the after-tax cash flows + Portfolio of Financial Options that allows the firm to reduce the tax liability on either domestic or foreign profits. Once we modify the investment analysis rule we are able to show that there is a benefit to investing abroad when tax rates are dynamic, even if the foreign location is a relatively high tax region.¹⁵ In addition, we can use the improved framework to decide between two competing foreign investment opportunities, not only by comparing the after-tax cash flows and the simple NPV, but also by comparing their contribution to global tax saving.

¹³ European options can only be exercised on a pre-determined date.

¹⁴ We include a parameter to capture the fact that all profits cannot be shifted from one country to another to be more realistic.

¹⁵ Refer to Appendix II and also refer to Muralidhar (1991a) for a different approach.

There is some discussion of similar issues in the literature on the value of multinational flexibility. Lessard and Paddock (1980), in a paper on the benefits of valuing international projects by components argues that there are three distinct components that can be readily identified. Projects produce cash flows that are fixed by contract (*debt equivalents*), respond closely to a set of underlying economic forces (*equity equivalents*), and “respond non-linearly to changes in some underlying cash flows or asset values”¹⁶ (*option equivalents*). Kogut (1985) has emphasized that multinational firms have flexibility which permits them to hedge against the uncertainty over future exchange rates, competitive moves or government policy.¹⁷ Kogut and Kulatilaka (1991) also indicate that the option to lower taxes is valuable, and that “this is of transparent concern to governments.”¹⁸ While these papers capture the importance of flexibility of the multinational enterprise, none of them explicitly value these options or show the extent to which NPV analyses may fall short of capturing the true value of investing in more than one country, when corporate tax obligations within specific tax jurisdictions are variable.

The key contribution of this paper is to draw on the literature discussing the value of flexibility of a MNE and combine it with the emerging literature of the option value of an investment, when investment is irreversible and when business environments are dynamic.¹⁹ NPV analyses may ignore the effect of volatility of the international tax environment. However, an options pricing model is provided to complement the NPV analysis and a valuation is performed to show how investment decisions can be affected by ignoring the value of financial flexibility.

In the next section we provide a model to value financial flexibility.

¹⁶ page 11.

¹⁷ page 27.

¹⁸ This is an isolated comment that is made in the concluding section of their paper, and no further explanation is provided - (page 21).

¹⁹ See Pindyck (1991) for a review of the literature on the option value of domestic investments. See Muralidhar (1991c) for a valuation of operational flexibility of a MNE. See Triantis and Hodder (1990) for a valuation of production mix flexibility.

Section II (Valuing Financial Flexibility)

In this section we demonstrate how a foreign project, by giving the MNE the option to shift some fraction of profits generated in a high tax region, to a low tax region, adds value over and above that which a static NPV analysis would suggest. We will use dynamic tax regimes as a way to model volatility and then value financial flexibility. We will ignore the other aspects of financial flexibility.²⁰ We provide a simple model that requires the assumptions outlined below.

Assumptions

- A.1 Assume that there are only 2 countries: countries A and B.
- A.2 The MNE has two factories, one each in country A and B, and each generates \$1 in (real) pre-tax profits in every period. We will assume that the MNE is domiciled in country A with a subsidiary in B.
- A.3 Outsiders (e.g. government agencies) can only observe global pre-tax profits (in this case \$2), and are unable to distinguish the exact contribution of the two plants to total profits. This is a fair assumption as governments have some difficulty in determining the exact contribution of any one plant to total firm profits.
- A.4 Of the \$1 generated by each unit in every period, the MNE has to declare a fraction $(1-\gamma)$ of this \$1 locally and the remaining fraction γ can be shifted²¹ to the location of choice costlessly.²²
- A.5 The effective marginal tax rate in A is τ^A ($0 \leq \tau^A \leq 1$) and the effective marginal tax rate in B is τ^B ($0 \leq \tau^B \leq 1$).
- A.6 Let $\Delta = [\tau^A - \tau^B]$, where $|\Delta|$ = tax saving on γ earned in a high tax region, and assume that fluctuations in Δ can be captured by the following stochastic process (Brownian Motion with No Drift) :

²⁰ We will not value the benefit to being multinational when exchange rates change or the benefit to raising capital at lowest cost by being able to access funds in different countries.

²¹ By this we mean any activity that shifts profits/cash flows from high tax jurisdictions to low tax jurisdictions (e.g. manipulation of transfer-prices on intra-company goods flows). For simplicity, we assume that the firm can change the direction of flows in every period costlessly.

²² The choice of γ is arbitrary and fixed (i.e. γ is exogenous), and we will address this assumption later in the paper.

$$d\Delta = \sigma dz^{23} \quad (1)$$

where $dz = \varepsilon(t)(dt)^{1/2}$ is the increment on standard Brownian Motion. $\varepsilon(t)$ has zero mean and unit standard deviation. $E[dz] = 0$ and $E[(dz)^2] = dt$, and σ is the instantaneous standard deviation.

- A.7 We assume that changes in tax rates are zero beta (uncorrelated with the market portfolio). This assumption ensures that all risks are spanned if markets are complete.
- A.8 Goal of management is to maximize the value of the firm. The value of the firm is the discounted sum of global after-tax cash flows. Since we are assuming that profits/cash flows are fixed, the goal of the firm could be translated into minimizing tax disbursements.
- A.9 Assume that the firm is risk-neutral.²⁴
- A.10 Let r be the real risk-free rate in A, and assume further that r does not change.
- A.11 Assume zero inflation.
- A.12 The system of taxation is territorial.²⁵

The Model

If the firm was national (multi-plant, single-country) then the value of the firm would be equal to the value of the first investment (factory) plus the value of the second investment. Using the traditional NPV analysis we find that

$$\text{Expected NPV}(\text{first inv.}) = E_t \left[\int_{t=0}^{\infty} e^{-rt} [1 - \tau^A(t)] dt \mid \tau_0^A = \tau^A \right] - I > 0 \quad (2)$$

²³ The stochastic process that we have chosen allows us to assume that both τ^A and τ^B vary, but we will treat τ^A as stochastic and τ^B as static to simplify the discussion. As we show in the Appendix, this is an acceptable assumption, and does not significantly affect our results.

²⁴ This is a crucial assumption. We cannot create a replicating portfolio to value these options, so we must assume that the firm is risk neutral. This is not an unrealistic assumption if we assume that managers in MNEs are risk-neutral.

²⁵ This assumption simplifies the valuation method. If we assumed a residency system, modeling tax saving would be more difficult and we would have to take into account foreign tax credits.

= Expected NPV(second inv.)²⁶

where r is the risk-free rate, $\tau^A(t)$ is the tax rate in A in time period t , and I is the sunk cost of investment.

On the other hand, if management locates a factory in both country A and country B, one would expect the value of the foreign investment in B to be given by (3).

$$\text{NPV (foreign inv.)} = E_t \left[\int_{t=t_1}^{\infty} e^{-rt} (1-\tau^B) dt \right] - e^{-rt_1} I. \quad (3)$$

This would be correct if the firm was forced to report all locally generated profits in the proper tax jurisdiction. However, we will argue that the true value of the foreign investment = NPV + Value of Portfolio of Call Options + Value of Portfolio of Put Options that allow the MNE to minimize its tax liability.

What are these options?

The tax savings that accrue from shifting a fraction of realized profits in the MNE to a low tax jurisdiction can be valued in the following manner :

When $\tau^A > \tau^B$, then the tax saving = $\gamma (\tau^A - \tau^B)$ because γ of the \$1 earned in country A is moved to country B; when $\tau^A < \tau^B$ then the tax saving is = $\gamma (\tau^B - \tau^A)$ following a similar argument. If the marginal tax rate in A follows a stochastic path then in every time period the firm has a "put" option when $\tau^A > \tau^B$ and a "call" option when $\tau^A < \tau^B$.

The first is a put option because the firm has the ability to "sell" a fraction γ that would have been taxed at τ^A for $\gamma\tau^B$ (where τ^B is pre-determined and τ^A

²⁶ This assumes that both investments are made at the same time. If the second investment is staggered, the NPV will not be the same. NPV(second inv.) =

$E_t \left[\int_{t=t_1}^{\infty} e^{-rt} (1-\tau^A(t)) dt \right] - \tau_0^A - e^{-rt_1} I$, where t_1 is the period in which the investment is made.

is stochastic) when $\tau^A > \tau^B$. The opposite is true for the call option because the firm has the option to "buy" γ at $\gamma\tau^B$ when $\tau^A < \tau^B$.

Valuing the Portfolio of Options : $F(\Delta)$

$d\Delta = \sigma dz$ where

$\Delta = (\tau^A - \tau^B) =$ taxes saved on γ when $\tau^A > \tau^B$

$\Delta > 0 \Rightarrow \tau^A > \tau^B$ and $\Delta < 0 \Rightarrow \tau^A < \tau^B$

The objective of the firm is to maximize tax-saving. Expressing it as a dynamic programming problem, we want to

$$\max_j E_t \int_{t=0}^{\infty} \gamma j(\Delta) e^{-rt} dt \quad (4)$$

where $j \in [-1, +1]$

$$F(\Delta) = \gamma \left(\max_{j=-1/1} E_t \int_{t=0}^{\infty} j(\Delta) e^{-rt} dt \right) \quad (4')$$

given that Δ follows the stochastic process specified in (1).

$$\text{Define } V(\Delta) = \max_{j=-1/1} E_t \int_{t=0}^{\infty} j(\Delta) e^{-rt} dt \quad (5)$$

$$\text{which implies that } F(\Delta) = \gamma V(\Delta).^{27} \quad (5')$$

The Bellman equation for the value of the portfolio of options $V(\Delta)$ is

$$rV = \max_{j=-1/1} \left\{ j(\Delta) + \frac{1}{dt} E_t dV \right\} \quad (6)$$

$$\text{By Ito's Lemma } dV = V'd\Delta + \frac{1}{2} V'' (d\Delta)^2 \quad (7)$$

where the prime denotes the derivative with respect to Δ .

$$dV = V'\sigma dz + \frac{1}{2} \sigma^2 V'' dt \quad (8)$$

²⁷ $V(\Delta)$ is the value of the options if the entire \$1 earned in the high tax country could be moved to the low tax country.

Substituting for (8) in equation (6) we find

$$rV = \max_{j=-1/1} \left\{ j(\Delta) + \frac{1}{2} \sigma^2 V'' \right\} \quad (9)$$

Maximizing with respect to j : set $j = 1$ if $\Delta > 0$ (declare γ earned at home in country B) and set $j = -1$ otherwise (declare γ earned in country B at home).

Therefore, we need to solve

$$\frac{1}{2} \sigma^2 V'' - rV + j(\Delta) = 0 \text{ subject to the following conditions:} \quad (10)$$

$$V(\Delta = -\infty) = -\frac{\Delta}{r} \quad (11a)$$

$$V(\Delta=0^-) = V(\Delta=0^+) \quad (11b)$$

$$V'(\Delta=0^-) = V'(\Delta=0^+) \quad (11c)$$

$$V(\Delta = \infty) = \frac{\Delta}{r} \quad (11d)$$

(11a) is a boundary condition and we assume that the value of the option approaches $-\frac{\Delta}{r}$ (which is the value of a perpetuity if $\tau^B = \infty$) and vice-versa for (11d).²⁸ The last condition is included because as τ^A becomes very large, the probability that the firm declares the γ earned in A locally goes to zero. Hence the value of the options is a perpetuity discounted by the risk free rate. (11b) and (11c) are the continuity and smoothness conditions.

$$V(\Delta) = a_1 e^{-\Delta g} + \frac{\Delta}{r} \quad \text{when } \Delta > 0 \quad (12a)$$

$$= a_2 e^{\Delta g} - \frac{\Delta}{r} \quad \text{when } \Delta < 0 \quad (12b)$$

where $g^2 = \frac{2r}{\sigma^2}$ and e is the base of the natural logarithm.

From the continuity conditions, at $\Delta = 0$ we find that $a_1 = a_2 = \frac{1}{rg}$.

$$[V'(\Delta = 0^+) = V'(\Delta = 0^-)]$$

$$\Rightarrow -gae^{-\Delta g} + \frac{2}{r} = gae^{\Delta g} \Rightarrow 2ag = \frac{2}{r} \text{ which is solved for } a]$$

²⁸ The boundary conditions are a bit extreme because we assume that τ^A and τ^B unbounded, but we will discuss the effect on $V(\Delta)$ when $0 \leq \tau^A \leq 1$ later in the paper, and in the Appendix.

$$V(\Delta) = \frac{1}{rg} e^{-\Delta g} + \frac{\Delta}{r} \quad \text{when } \Delta > 0 \quad (13a)$$

$$= \frac{1}{rg} e^{\Delta g} - \frac{\Delta}{r} \quad \text{when } \Delta < 0 \quad (13b)$$

From (5') we can conclude that

$$F(\Delta) = \frac{\gamma}{rg} e^{-\Delta g} + \frac{\gamma \Delta}{r} \quad \text{when } \Delta > 0 \quad (14a)$$

$$= \frac{\gamma}{rg} e^{\Delta g} - \frac{\gamma \Delta}{r} \quad \text{when } \Delta < 0 \quad (14b)$$

The value assigned to $F(\Delta)$ stems from two facets; namely, the value of transactions conducted presently and the value of future opportunities. (14a) states that when $\tau^A > \tau^B$, and assuming τ^A never changes, the γ earned in A is going to be moved to country B in all future periods and the present value of these transactions = $\frac{\gamma \Delta}{r}$. However, should $\Delta < 0$, management would want to discontinue this practice and the option to stop conducting these transactions = $\frac{\gamma}{rg} e^{-\Delta g}$. (14b) states a similar result except that now $\Delta < 0$ and therefore $-\frac{\gamma \Delta}{r} > 0$, and hence money is flowing from country B to country A.

The discussion above indicates that the corrected value of the foreign investment, ignoring the real flexibility, is the simple NPV outlined in equation (3), plus the value of the financial options that the foreign investment brings to a parent company domiciled in country A. Hence the value of a foreign investment in B, to a parent company in A would be

$$= \int_{t=t_1}^{\infty} e^{-rt} (1-\tau^B) dt - e^{-rt_1} I + F(\Delta) \quad (15)$$

Section III

Section III is presented with two sub-sections : A and B. In Section III A we conduct sensitivity analyses to show how the value of $F(\Delta)$ is affected by the parameters and the choice of parameter values. We then use the model solved above to show how an omission of the value of flexibility leads to an incorrect rejection of a project in a foreign country. However, MNEs that recognize that the investment abroad adds value to the existing organization are shown to acquire the project that domestic investors in the foreign country reject. In Section III B we use the model derived above to compare the value of financial flexibility (for a US-based MNE) provided by investments in different countries. We utilize corporate tax rate data for 1984-1990 to show how the valuation of projects in countries like Australia, Canada, Denmark, Germany, Italy, Japan and the UK will be affected by an exclusion of the value of financial flexibility.

Section III A

In this model there are a few key variables; namely, the interest rate, volatility of tax regimes, the fraction of total profits that can be transferred, the tax rate in A and the tax rate in B. In the tables below we investigate the impact of different parameter values on $F(\Delta)$, and the possible effect on an NPV calculation.

For our analysis in Table 1 we focus on a real interest rate of 3%, $\gamma = 15\%$ and a $\sigma = 0.07$. The measure of σ was arrived at from corporate tax rate data for the U.S. and the UK (1947-80).²⁹ We assume that this measure of volatility is appropriate as of 1991. We choose a tax rate of 34% in the home country to represent the current U.S. corporate tax rate. Other values were arbitrarily chosen to illustrate some examples.

²⁹ King and Fullerton (1984), pages 43 and 203. $\sigma(\tau^A - \tau^B) = 6.6\%$, which we approximate to 0.07. Refer to Appendix III and Graphs 1 and 2.

**Graph 2 - Differences in Corporate Tax Rates
US Tax Rate - UK Tax Rate (1947 to 1980)**

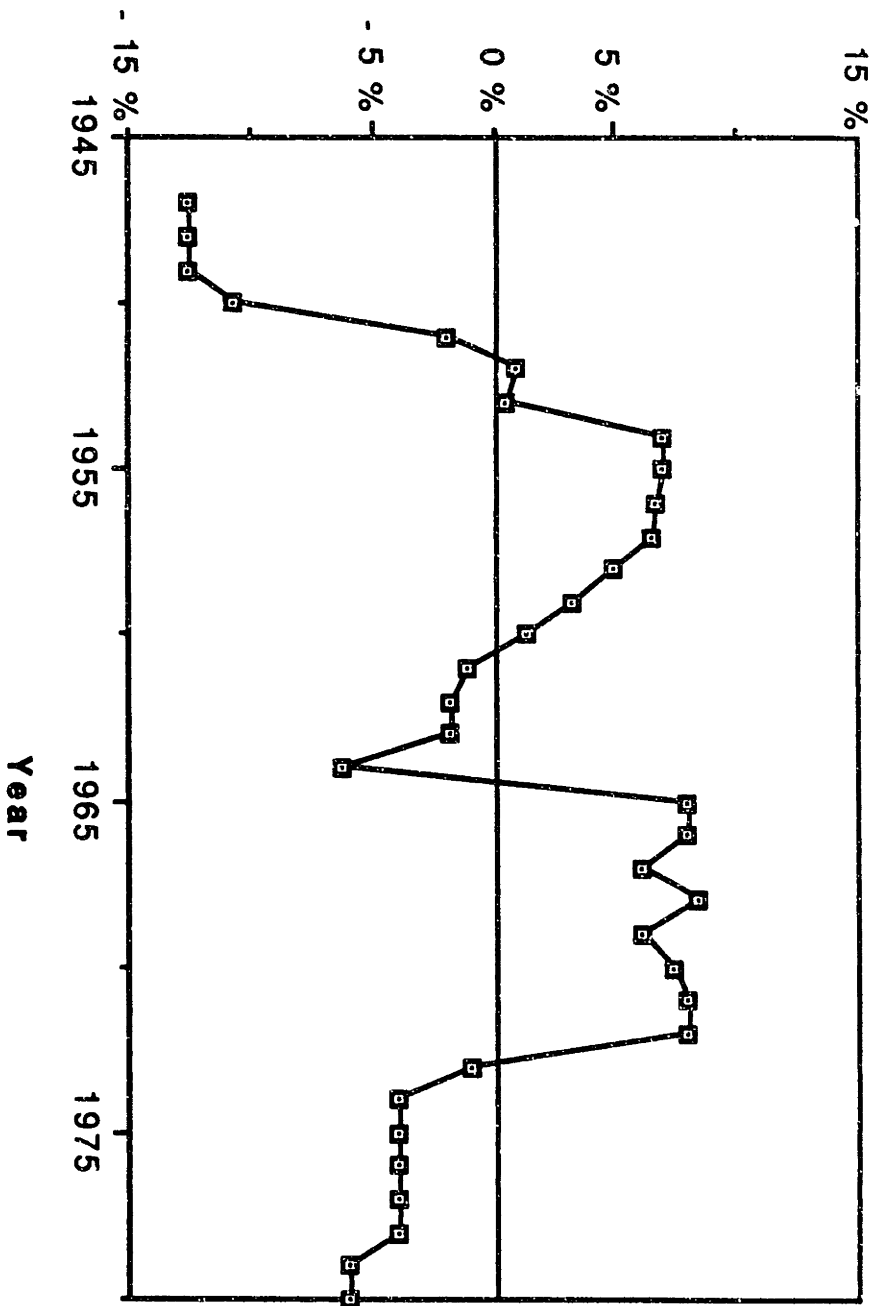


Table 1 - Valuing Financial Flexibility

Assume that the sunk cost of investment (I) = 21. The investment in B provides \$1 of real pre-tax CFs/ year.

	Int. Rate r (%)	Std. Dev. σ (%)	Percent of Profit Hidden	Tax Rate in A (%)	Tax Rate in B (%)	$\Delta =$ ($\tau^A - \tau^B$)	PV of after-tax CF in B = ($1 - \tau^B$)/r	Static NPV = (7) - I	F(Δ)	Adj. NPV = (8) + (9)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	Varying 2	Int. Rate 7	15	34	40	-0.06	30	9	2.66	11.66
(2)	2.5	7	15	34	40	-0.06	24	3	1.91	4.91
(3)	3	7	15	34	40	-0.06	20	-1	1.46	0.46
(4)	Varying 3	Volatility 4.5	15	34	40	-0.06	20	-1	0.96	-0.04
(5)	3	5	15	34	40	-0.06	20	-1	1.06	0.06
(6)	3	5.5	15	34	40	-0.06	20	-1	1.16	0.16
(7)	3	6	15	34	40	-0.06	20	-1	1.26	0.26
(8)	Varying 3	τ^A 7	15	30	40	-0.10	20	-1	1.51	0.51
(9)	3	7	15	35	40	-0.05	20	-1	1.45	0.45
(10)	3	7	15	40	40	0.00	20	-1	1.43	0.43
(11)	3	7	15	45	40	0.05	20	-1	1.45	0.45
(12)	Varying 3	Percent of 7	5	34	40	-0.06	20	-1	0.47	-0.53
(13)	3	7	10	34	40	-0.06	20	-1	0.97	-0.03
(14)	3	7	15	34	40	-0.06	20	-1	1.46	0.46
(15)	3	7	20	34	40	-0.06	20	-1	1.94	0.94

where CF = Cash Flow, PV = Present Value, and F(Δ) = Value of Financial Flexibility

From Table 1 we can conclude that

- Even if the tax rates in the two countries are equal, $F(\Delta) > 0$ (row 10, column 10).
- As the interest rate rises, $F(\Delta)$ declines (rows 1-3).
- $F(\Delta)$ increases as the volatility of Δ increases (rows 4-8).
- $F(\Delta)$ is an increasing function of the absolute value of Δ (rows 8-11).
- Higher the percentage of profits that can be transferred to a low tax region, the higher the value of $F(\Delta)$ (rows 12-15).

$F(\Delta)$ is non-zero, even if $\tau^A = \tau^B$, because $F(\Delta)$ represents the present value of all future tax-saving, and even if tax rates are equal today, they need not be in the future. Hence investing today in a foreign location is valuable. However, if real interest rates increase, then the present value of future tax-saving is lowered, in turn lowering $F(\Delta)$. Further, a higher σ indicates that the tax rate in the foreign location moves in a fashion that is contrarian to the tax rate changes at home. This provides a greater benefit to the MNE, as it diversifies its tax portfolio. If the investment is made today, the firm is guaranteed a relatively low tax jurisdiction for a large fraction of its global profits, especially if tax rates at home increase.

We are able to conclude that $F(\Delta)$ is an increasing function of the absolute value of Δ because the firm is able to move profits in both directions (i.e. the firm acquires both put and call options). Another interesting result from this analysis is that the impact on $F(\Delta)$ from changes in Δ and from changes in σ differ quite significantly. As the tax rate in A approaches that of B, the value of $F(\Delta)$ falls, making the foreign investment seem less attractive (rows 8-10). This follows because now profits transferred from B to A are taxed at a higher rate. Moreover, it appears that changes in volatility have a greater impact on $F(\Delta)$, and a cursory glance at the figures reveals that the elasticity of F with respect to σ is greater than the elasticity of F with respect to Δ . This observation may have some policy consequences.

While the selection of I (sunk cost of investment) is arbitrary, Table 1 clearly shows how an investor in country B might not be willing to invest in this

project because of its negative NPV (column 8). However, a multinational firm sees the project as an integral part of the multinational network and could be willing to sink I to acquire a plant in country B (column 10). For a firm domiciled in A, investing in more than one country enhances the value of existing investments and increases firm value, in turn providing justification (in some situations), for the firm to invest in country B.

Section III B

We were able to obtain corporation income tax rates (which combines national and local tax rates) for the U.S., and a host of developed countries for 1984-1990.³⁰ While the time series is limited, the calculation of the corporate tax rate is consistent for all the countries and hence makes our comparison interesting. The interesting result we derive is that for MNEs, the co-variability of the foreign tax rate with the home tax rate, may be more important than the individual volatility of the tax rate of the foreign country.³¹

We assume that $r = 3\%$, $\gamma = 15\%$, $\tau^{US} = 39\%$ ³², and that the investment provides \$1 of pre-tax cash flows in every year. We examine the contribution to firm value of projects in Australia, Canada, Denmark, Germany, Italy, Japan and the UK to a U.S.-based MNE. The comparison is based on data as of 1990, and summary statistics are provided in Table 2. Except for the US, the countries have been arranged in ascending order of tax rates as of 1990.

As we can see from the Table 3, row 3, lower tax countries have higher expected present values of after-tax cash flows than high tax countries. Further, countries like Canada and the UK have lower measures of volatility *vis-a-vis* the US (row 2b) than countries like Denmark or Germany, which in turn would account for the relatively low values of financial flexibility for projects in these countries (refer to row 4).

There are two interesting comparisons to be made : (i) between Germany and Denmark, and (ii) between Canada and Italy. Both Germany and Denmark have the same tax rate = 50%. However, the higher measure of volatility ($\sigma(\tau^{US} - \tau^i)$) for Denmark (8.4%) as compared to Germany (5.4%) implies that a project in Denmark provides more value from financial flexibility than a similar project in Germany. Therefore, a U.S.-domiciled MNE would prefer

³⁰ Data is presented in Appendix III. Source : *World Tax Reform*. Some of tax rates provided in this publication are based on estimates derived from official government publications.

³¹ Also refer to Appendix II.

³² The 39% Corporate Income Tax Rate = 34% National Rate + 5% Average of State/Local Rates

Table 2 - Summary Statistics on Tax Data (1984-1990)

	The U.K.	Canada	Italy	Australia	Germany	Denmark	Japan	U.S.
1) Marginal Tax Rate (1990)	35%	44%	46%	49%	50%	50%	52%	39%
2) Mean Marginal Tax Rate	37%	49%	45%	48%	55%	49%	52%	45%
3) $\sigma(\tau^i)$	3.9%	3.9%	3.8%	1.6%	2.3%	3.8%	0.5%	6%
4) $\sigma(\tau^{us} - \tau^i)$	4.6%	3.3%	8.4%	7.5%	5.4%	8.4%	5.5%	N.A.

Tax Rate in the U.S. (1990) = 39% (34% = National + 5% = Average of State Tax Rates)

Tax rates = Corporation Income Tax Rates (which combines National and Local Tax Rates)

Table 3 - Comparing Foreign Countries for a US-based MNE

	The U.K.	Canada	Italy	Australia	Germany	Denmark	Japan
1) Marginal Tax Rate (1990)	35%	44%	46%	49%	50%	50%	52%
2a) $\sigma(\tau^i)$	3.9%	3.9%	3.8%	1.6%	2.3%	3.8%	0.5%
2b) $\sigma(\tau_{us} - \tau^i)$	4.6%	3.3%	8.4%	7.5%	5.4%	8.4%	5.5%
3) PV of After-Tax Cash Flows*	21.67	18.67	18.00	17	16.67	16.67	16
4) $F(\Delta)$ = Value of Finan. Flexibility	0.96	0.71	1.74	1.6	1.22	1.79	1.28
5) Adjusted Present Value = (3) + (4)	22.63	19.38	19.74	18.6	17.89	18.46	17.28
6) $F(\Delta)$ as a % of Adj. PV = (4)/(5)	4.2%	3.7%	8.8%	8.6%	6.8%	9.7%	7.4%

Value of Project assuming that each investment produces \$1 in real pre-tax cash flows in every period
 Percent of Profits Shifted (γ) = 15%; Real interest rate = 3%

* At current marginal tax rates

the investment in Denmark to the investment opportunity in Germany, even though the expected present value of after-tax cash flows are equal.

A more interesting result is derived from comparing the value of a project in Canada to a similar project in Italy. The lower tax rate in Canada (44%) *vis-a-vis* Italy (46%) provides higher after-tax cash flows to the U.S. parent. However, Canadian tax rates are more correlated with U.S. tax rates ($\sigma(\tau^{\text{US}} - \tau^{\text{C}}) = 3.3\%$) than are Italian tax rates ($\sigma(\tau^{\text{US}} - \tau^{\text{I}}) = 8.4\%$), and if we include the value of financial flexibility provided by an investment in these two countries, we find that the Italian project is preferred to the Canadian project (line 5)! Hence, we get the seemingly counter-intuitive result that the American parent should invest in the relatively higher tax location, even though pre-tax rates of return are the same in the two countries.³³

These results could be criticized on the grounds that the calculations have ignored the fact that a country with a high measure of volatility may also have a higher average marginal tax rate³⁴ for the period under consideration, in turn negating the professed value of financial flexibility. However, from the data provided in the Table 2 we can see that the average tax rate for Italy (45%) is less than the average tax rate for Canada (49%). This is also true for Denmark (49%) and Germany (55%).

We can summarize the comparison along two dimensions; namely, marginal tax rates in 1990 and correlation (volatility) of foreign tax regimes with the U.S. As the matrix in Figure 1 shows, a project in a low tax country with a high measure of volatility dominates a similar project in a high tax country with either high or low measures of volatility. However, a project in a low tax country with a low measure of volatility (highly correlated with movements in tax rates in the US) need not always dominate a project in a relatively high tax country.

³³ We have not compared investing in the US to investing abroad. If management were to invest in the US, with $\tau^{\text{US}} = 39\%$ and $\sigma_{\text{US}} = 6\%$, the value of a domestic investment with a similar pre-tax cash flow = \$20.67. It can be shown that if the tax rate in Italy falls to 43%, everything thing else equal, investing in Italy would dominate investing in the US. Refer to Appendix II for this result.

³⁴ The average of the marginal tax rates.

Figure 1 - Comparing Countries Along Two Dimensions
Present Tax Rates versus Volatilities (σ)
 (High Volatility implies low correlation with the US and $v.v$)

	High Tax, High Volatility Countries	High Tax, Low Volatility Countries
Low Tax, High Volatility Countries	<p>Low Tax Preferred to High Tax</p> <p>1) Italy (46%, 8.4%) > Australia (49%, 7.5%) 2) Australia (49%, 7.5%) > Denmark (50%, 8.4%)</p> <p>(Low Tax, High σ dominates)</p>	<p>Low Tax Preferred to High Tax</p> <p>1) Australia (49%, 7.5%) > Germany (50%, 5.4%)</p> <p>(Low Tax, High σ dominates)</p>
Low Tax, Low Volatility Countries	<p>No Clear Preference</p> <p>A. (Low Tax, Low σ dominates)</p> <p>1) U.K. (35%, 4.6%) is the best.</p> <p>B. (High Tax, High σ could be preferred to Low Tax, Low σ)</p> <p>1) Italy (46%, 8.4%) > Canada (44%, 3.3%)</p>	<p>Low Tax Preferred to High Tax</p> <p>1) U.K. (35%, 4.6%) > Canada (44%, 3.3%)</p> <p>(Low Tax, Low σ dominates)</p>

* where Canada (44%, 3.3%) implies that the Marginal Corporation Income Tax Rate = 44%, and $\sigma(r^{us}-r^{can}) = 3.3\%$

Finally, if we examine the value of financial flexibility as a percentage of total project value (refer to Table 3, row 6), we can conclude that for countries where the measure of volatility is relatively high³⁵, including the value of flexibility for projects in these countries is more significant than it is for projects in Canada and the UK. In conclusion, from the data provided it is clear that excluding the value of financial flexibility from project valuation could cause management to make sub-optimal decisions regarding the acceptance and/or the location of investment.

³⁵ Countries where the tax rate is less than perfectly correlated with U.S. Countries include Italy, Denmark, Japan and Australia.

Section IV

Since we make some simplifying assumptions to construct the model and arrive at predictive results, we now consider some extensions to the analysis. These extensions or modifications focus both on the mathematical techniques used and on the assumptions made to derive the value of $F(\Delta)$.

This model is quite robust because we assumed that a MNE would declare some fraction $(1 - \gamma)$ of profits locally and shift an exogenously determined fraction γ to a low tax region. This is not a restrictive assumption and hence makes the model more credible and useful. We can allow γ to take any value depending on the intensity with which the subsidiary's operations are scrutinized by domestic agencies. Notice that the strong assumption that we made was that outsiders could observe only global profits and not the contribution of the individual factories to total profits. This would lead us to believe that governments may invest some of their resources to discern the true profitability of domestic operations, regardless of whether these organizations are parent companies or foreign-owned subsidiaries. This would impose a cost on the firms, and therefore any costs that are imposed on the firm by this monitoring may need to be included into the final calculation.³⁶ By introducing this cost of being detected into the calculations, we may be forced to determine γ endogenously.

The only weak link in the mathematical model is that we assumed that τ^A and τ^B were unbounded rather than bounded by $[0,1]$. We could address this by assuming a different stochastic process and throwing in absorbing barriers. Instead, if we assumed reflecting barriers at 0 and 1, the value of the portfolio of options might change significantly. Alternatively, it could be argued that changes in taxes could be captured by a Poisson Process or a Mean Reverting Process, but then closed form solutions, like those provided in Section II, are not guaranteed and numerical solutions will have to be provided.³⁷ However, the key contribution of this paper is to suggest that we rethink the

³⁶ The U.S. is attempting to monitor foreign firms more closely than ever before in an attempt to prevent transgressions by multinational firms. See Delmar (1991).

³⁷ The benefit to using Mean Reverting and Poisson Processes is that they will allow for a comparison of the mean values of the underlying variables.

simple NPV rules by including the notion of valuing this portfolio of options, and hence we use the simplest model to make our point.

This approach abstracts from reality by assuming that subsidiaries can be controlled by the Chief Financial Officer of the parent company. Since managers in subsidiaries have an incentive to report profits locally rather than transfer them to another business unit, the parent company will have to design incentive schemes to encourage managers of subsidiaries in high tax countries to move profits to other locations. Most MNEs do maintain two sets of records. One is for the tax authorities (legal entity) and one is for the "real" profitability that becomes the basis for measurement of management's performance.

In Section III B we provided a comparison between a few developed countries. However, the measures of volatility that we derived were extracted from a limited sample of data because of data constraints. It would be interesting to see whether these measures change dramatically when we extend the time series. For example, the standard deviation of the difference in tax rates in the UK and the U.S. was 6.6% for the 1947-80 period (from Appendix III). This drops considerably to 4.6% when the time series is shortened to 1984-1990 (from Table 2). On the other hand, if we believe that data prior to the 1980s may not reflect recent trends in tax policy (e.g. the move towards policy coordination in some countries), then calculating volatility from this data may be acceptable.

Two other extensions to this model would include providing an assessment of the value of flexibility when the tax system is residential and when we account for exchange rate fluctuations. We may not have trouble valuing flexibility under the residency system as long as we can model tax saving as a stochastic process, like we modeled tax regimes in our example. With respect to accounting for flexibility when exchange rates are volatile, the approach may be computationally more difficult as we have to model how exchange rate variations affect the taxable status of subsidiaries, but we expect that similar results will hold. To incorporate this aspect of financial flexibility we will have to forecast the sensitivity of cash flows in subsidiaries to changes in exchange rates. However, we should find that the greater the ability to move

profits and the greater the volatility in exchange rates, the greater the benefit to being multinational. This problem provides fertile ground for future research.

Section V

The literature on financial flexibility of the MNEs has repeatedly pointed out how MNEs can minimize their tax liability by creative transfer-pricing.³⁸ We have shown that this flexibility can be valued quite easily and that this valuation could be critical when firms are making investment decisions. While the value of financial flexibility ($F(\Delta)$) is clearly positive, our parameter selection shows that the value could be significant as an inclusion of $F(\Delta)$ can affect the final investment decision.³⁹ Further, the lower the interest rate, the higher the volatility (lower the degree of positive correlation), the higher the fraction of profits transferred and the wider the spread between the two tax rates, the greater the value of $F(\Delta)$. In Muralidhar (1991a) we show why a firm might invest in a relatively high tax country with lower tax rate volatility than the home country in anticipation of possible tax rate changes at home.⁴⁰ As can be seen from the above, with small modifications to our model, a very similar conclusion can be derived.⁴¹

If firms lay significant emphasis on tax savings as a way to increase firm value, then governments around the world that wish to encourage investment should take note. The policy implications from such a model are that host countries (and even home countries) should recognize that a firm that is multinational reveals itself to be one that would take advantage of any differences between tax regimes in various countries. Any country that is considered a high tax jurisdiction should ensure that it has in place a system to monitor the true profitability of multinational operations. This will ensure that profits are not consistently moved to tax havens, in turn ensuring that local governments receive their fair share of locally generated profits.

³⁸ References include Horst (1976), Hines (1990), Hines and Rice (1990) and Lessard (1979).

³⁹ While tax factors may not be the sole reason for investment, an inclusion of financial flexibility may provide the required cushion for comfort for marginal projects.

⁴⁰ We use an infinite period, discrete time model where the uncertainty about future tax rates is resolved after period 2. However, firms have to make investment decisions while there is still uncertainty about future tax rates. The purpose of this paper is to show that when tax regimes are independent and changing, even if all product markets are perfectly competitive, we still have a necessary and sufficient condition for why firms would want to be multinational.

⁴¹ Refer to Appendix II for a discussion of this extension.

The US seems to be taking measures to impose penalties on organizations suspected of manipulating transfer-prices. MNEs like the Sundstrand Corporation and Bausch and Lomb are learning that IRS audits are costly not only in terms of disrupting operations, but also in terms of the legal costs of defending existing business practices.⁴² While on the one hand more aggressive monitoring by the IRS guarantees a higher probability that firms will not cheat on their taxes, on the other, it may cause prospective investors to regard the US as a hostile environment. The trade-off to be considered by the government is whether an increase in tax revenue from a transformation of reporting practices offsets the loss in social welfare from reduced investment.

This research may have some applications in understanding how to attract investment from domestic and foreign sources. The message from Muralidhar (1991a) was that a lowering of tax regime instability may be more effective in attracting investment than a lowering of tax rates (or offering tax incentives or tax subsidies). While our approach does not explicitly provide such a result, we can conclude that an increase in the volatility of tax regimes ($\sigma(\tau^{us} - \tau^i)$) raises the value of multinationality and increases the probability that domestic firms will consider multinationality. Policy coordination, will prevent countries from engaging in destructive tax competition and save them valuable resources that otherwise would have been directed towards preventing tax evasion.⁴³

The results of this paper indicate that effective financial management can be lead to significant increases in firm value. Therefore, the greater the volatility in business environments, the greater the value of multinational enterprises that can internalize financial flexibility. An interesting empirical question, that is beyond the scope of this paper, is whether stock markets recognize that the expected value of MNEs increase when there is increased uncertainty about future tax regimes in host countries. This question could provide new avenues for research in the area of international taxation and MNEs.

⁴² Refer to Delmar (1991), "The Tax Man Cometh."

⁴³ For example see the discussion in Giovannini (1989).

Conclusions

It has been suggested that investment spending on an aggregate level may be highly sensitive to risks arising from variability in tax regimes.⁴⁴ However, these views have focused their attention on national firms and very little attention has been paid to the impact of co-variation of tax regimes in different countries, and their impact on investment decisions for MNEs.

MNEs or else firms considering multinationality should be careful to recognize that investments in more than one country or in different business environments are valuable because of the flexibility that these investments create for the entire multinational system. In this paper, we have demonstrated how changing tax rates and the ability of the MNE to transfer some fraction of pre-tax profits to relatively low tax regions can be valued using derivative asset pricing models. The value of the flexibility depends critically on the degree of correlation in tax regimes and quite obviously, the less correlated the tax regimes, the greater the value to being multinational. Finally, the paper shows how simple NPV rules should be enhanced and our calculations indicate that for U.S.-based MNEs an inclusion of the value of financial flexibility may be more important for projects in Germany, Denmark, Japan and Australia than they would be for projects in Canada and the UK. Specifically, we were able to demonstrate the counter-intuitive result that an investment in a relatively high tax country like Italy could be preferred to a similar investment in a lower tax country like Canada. This follows because the Italian investment provides a U.S. parent higher expected tax saving than an equivalent investment in Canada.

⁴⁴ See for example Pindyck (1991) on the policy implications of irreversibility of investments when domestic environments are volatile.

Appendix I

Examples of transactions that allow firms to transfer profits without changing transfer prices

Most discussions of profit shifting by MNEs focus their attention on changing transfer-prices on inter-company real and financial transactions. In addition, the corporate treasury can adjust the timing of inter-company receivables/payables, which in turn shifts interest costs from one location to another. These two methods are useful, but these transactions are subject to regulation by tax authorities.

Other methods employed by MNEs to shift profits can be quite innovative. If there are a number of stages in the value-added chain, the parent company can set low and high markups for the different stages. Thereafter, sourcing for the various subsidiaries can take place at different stages in the value added chain. For example, if profits are to be transferred from India to the U.S. then the parent company in the U.S. can ask the Indian subsidiary to source inputs with the highest markups from the U.S. parent. If the parent would like to move funds to India, then it will encourage the Indian subsidiary to purchase inputs from other levels of the value added chain where the markups are much lower.

Another method to transfer profits includes the provision of discounts, promotions, and samples to subsidiaries that are not explicitly tied to sales. Since these discounts/promotions are not explicitly tied to sales, their connection to transfer prices is tenuous. However, they achieve the same goal of moving profits to the desired location that changes in transfer prices do, and are subject to less regulatory inspection.

Appendix II - Assume that both τ^A and τ^B are stochastic

Define $\Delta = (\tau^A - \tau^B)$ (1)

Assume that $d\tau^A = \sigma_A dz$ and that $d\tau^B = \sigma_B dz$ (2)

Thereafter we can assume that $d\Delta = d(\tau^A - \tau^B) = \sigma dz$ (3)

because the difference between two Brownian Motions is also a Brownian Motion, if the joint distribution is also a Brownian Motion.

We should be concerned whether the expected value of after-tax cash flows in the foreign location are significantly affected by assuming that τ^B is stochastic.

Expected Present Value of the Foreign Project (excluding Flexibility)

$$= E_t \left[\int_{t=0}^{\infty} e^{-rt} [1-\tau^B(t)]^+ dt \mid \tau_0^B = \tau^B \right] \quad (5)$$

where $d\tau^B = \sigma_B dz$ and $[1-\tau^B(t)]^+ = \max [1-\tau^B(t), 0]$

With appropriate boundary, continuity and smoothness conditions it can be shown that the Expected Present Value of the Foreign Project (excluding Flexibility)

$$= \frac{1}{2rg} e^{-(1-\tau^B)g} + \frac{1-\tau^B}{r} \quad \text{when } \tau^B \leq 1 \quad (6a)$$

$$= \frac{1}{2rg} e^{(1-\tau^B)g} \quad \text{when } \tau^B \geq 1 \quad (6b)$$

where $g^2 = \frac{2r}{\sigma_B^2}$ and e is the base of the natural logarithm.

Notice from (6a) that if we assume that tax rates are unchanged, then the present value of after-tax cash flows = $\frac{1-\tau^B}{r}$. However, if τ^B exceeds 1 (i.e. more than a 100%) then $\frac{1}{2rg} e^{-(1-\tau^B)g}$ is the value of the option to stop earning profits if $\tau^B \geq 1$. We find for reasonable parameter values that this

term is approximately zero.⁴² Moreover, there is no known case where $\tau^B \geq 1$, and hence a good approximation of the expected present value of after-tax cash flows = $\frac{1-\tau^B}{r}$.

In Table 3A we show the effect of correcting for stochastic tax rates on the expected present value of after-tax cash flows. Further, we can show that the value of investing in the US when $\tau^{us} = 39\%$ and $\sigma_{us} = 6\%$, with a similar pre-tax cash flow = \$20.67, which is higher than the value of this project in all other countries, except the UK ($\tau^{uk} = 39\%$). However, from our results in Section III B, we might find in the future that investing in Italy, for example, may dominate investing in the US if the Italian tax rate was lowered (to say 42%).

⁴² These values range from zero for Australia, Germany and Japan to 5 to 10 cents for the U.K., Canada and Italy. Table 3 B provides a summary of the impact on expected after-tax cash flows from an inclusion of $\frac{1}{2rg} e^{-(1-\tau^B)g}$.

Table 3A - Assuming that Tax Rates in the Foreign Country are Stochastic

	The U.K.	Canada	Italy	Australia	Germany	Denmark	Japan	US
1) Marginal Tax Rate (1990)	35%	44%	46%	49%	50%	50%	52%	39%
2) $\sigma(\tau^i)$	3.9%	3.9%	3.8%	1.6%	2.3%	3.8%	0.5%	6%
3) $\sigma(\tau^{us} - \tau^i)$	4.6%	3.3%	8.4%	7.5%	5.4%	8.4%	5.5%	N.A.
4a) Exp. PV of After-Tax Cash Flows	21.67	18.67	18.00	17.00	16.67	16.67	16.00	20.33
4b) Exp. PV of After-Tax CFs (assuming that tax rates are stochastic)	21.71	18.74	18.08	17.00	16.67	16.77	16.00	20.67
5) $F(\Delta)$ = Value of Flexibility	0.96	0.71	1.74	1.6	1.22	1.79	1.28	N.A.

Appendix III - Data for Tables 3-5 : Tax Rates in Developed Countries

Year	Sweden	Denmark	France	Netherlands	UK	Germany	Italy	Canada	Australia	Japan	US
1990	52%	50%	42%	42%	35%	50%	46%	44%	43%	52%	39%
1989	52%	50%	42%	42%	35%	56%	46%	44%	49%	52%	39%
1988	52%	50%	42%	42%	35%	56%	46%	48%	49%	52%	39%
1987	52%	50%	45%	42%	35%	56%	46%	52%	49%	52%	45%
1986	52%	50%	45%	43%	35%	56%	46%	53%	46%	53%	51%
1985	52%	50%	50%	43%	40%	56%	46%	52%	46%	53%	51%
1984	52%	40%	50%	43%	45%	56%	36%	51%	46%	53%	51%
Average	52%	49%	45%	42%	37%	55%	45%	49%	48%	52%	45%
Std. Dev.	0.00%	3.78%	3.58%	0.53%	3.93%	2.27%	3.78%	3.85%	1.60%	0.53%	6.00%
Corporation Income Tax Rates : Combined National and Local Tax Rates											
Source : World Tax Reform											
US - Foreign Country											
Year	Sweden	Denmark	France	Netherlands	UK	Germany	Italy	Canada	Australia	Japan	US
1990	-13%	-11%	-3%	-3%	4%	-11%	-7%	-5%	-10%	-13%	
1989	-13%	-11%	-3%	-3%	4%	-17%	-7%	-5%	-10%	-13%	
1988	-13%	-11%	-3%	-3%	4%	-17%	-7%	-9%	-10%	-13%	
1987	-7%	-5%	0%	3%	10%	-11%	-1%	-7%	-4%	-7%	
1986	-1%	1%	6%	8%	16%	-5%	5%	-2%	5%	-2%	
1985	-1%	1%	1%	8%	11%	-5%	5%	-1%	5%	-2%	
1984	-1%	11%	1%	8%	6%	-5%	15%	0%	5%	-2%	
Average	-7%	-4%	0%	3%	8%	-10%	0%	-4%	-3%	-7%	
Std. Dev.	6.00%	8.38%	3.29%	5.50%	4.63%	5.40%	8.38%	3.29%	7.52%	5.50%	

Table - Corporate Tax Rates in the US and UK (1947 - 1980)

Year	UK Tax Rate	US Tax Rate	US - UK
1947	50.50%	38.00%	-12.50%
1948	50.50%	38.00%	-12.50%
1949	50.50%	38.00%	-12.50%
1950	52.75%	42.00%	-10.75%
1951	52.75%	50.75%	-2.00%
1952	51.00%	52.00%	1.00%
1953	51.50%	52.00%	0.50%
1954	45.00%	52.00%	7.00%
1955	45.00%	52.00%	7.00%
1956	45.38%	52.00%	6.63%
1957	45.50%	52.00%	6.50%
1958	47.00%	52.00%	5.00%
1959	48.75%	52.00%	3.25%
1960	50.63%	52.00%	1.38%
1961	53.13%	52.00%	-1.13%
1962	53.75%	52.00%	-1.75%
1963	53.75%	52.00%	-1.75%
1964	56.25%	50.00%	-6.25%
1965	40.00%	48.00%	8.00%
1966	40.00%	48.00%	8.00%
1967	41.88%	48.00%	6.13%
1968	44.38%	52.80%	8.43%
1969	43.13%	49.20%	6.08%
1970	40.63%	48.00%	7.38%
1971	40.00%	48.00%	8.00%
1972	40.00%	48.00%	8.00%
1973	49.00%	48.00%	-1.00%
1974	52.00%	48.00%	-4.00%
1975	52.00%	48.00%	-4.00%
1976	52.00%	48.00%	-4.00%
1977	52.00%	48.00%	-4.00%
1978	52.00%	48.00%	-4.00%
1979	52.00%	46.00%	-6.00%
1980	52.00%	46.00%	-6.00%
Average	48.43%	48.55%	0.12%
Std. Dev.	4.85%	4.13%	6.66%

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CHAPTER 3

"Valuing the Operational Flexibility of a Multinational Enterprise (with Implications for Investment Location and Capacity Choice Decisions)"

Abstract

A multinational firm has the option to switch production to the lowest cost location when either factor prices or exchange rates change, and we argue that NPV analyses may not capture the value of this operational flexibility. We introduce an options pricing model to value flexibility and offer an adjusted NPV calculation that incorporates the value of these real options. Once we revise the investment rule, we compare the costs of acquiring operational flexibility to the value that a foreign investment adds to existing investments. We show that in some cases valuable projects may be rejected if the value of flexibility is not included. The model is also used to compare competing investment locations and to comment on optimal location, capacity choice (and investment timing) decisions. The paper is tested with wage data for a host of countries and concludes by discussing the implications of such an approach for U.S.-based MNEs.

Introduction

As the global economic environment undergoes a rapid transition we are presented with a situation where doing business, whether in a national or international context, is fraught with uncertainty. Previously centrally-planned economies are gravitating towards a free market system and traditionally lesser developed economies are undergoing a metamorphosis through fiscal prudence and emphasis on growth. This paper will attempt to illuminate business risks that arise from volatility in specific markets and show how these may affect strategic decisions that firms must make once they choose to be multinational in this dynamic business environment.

Multinational enterprises (MNEs) that are able to respond rapidly to changing business conditions will gain the competitive advantage in the global market. As competition between MNEs takes place along a number of dimensions, the competitive position of the organization will be affected by the following : uncertain demand for products;¹ changes in the cost of mobile and immobile inputs in different countries; volatile exchange rates; revisions in government policy agendas; and innovations in process and product technology.

The strategic management literature has focused its attention on encouraging managers in MNEs to implement strategies that provide operational flexibility.² For example, multiple sourcing relationships allow MNEs to mitigate losses that stem from unanticipated changes in input costs in a particular country or from adverse exchange rate movements. In addition, firms have been encouraged to invest in flexible technologies that allow automated production lines to switch from the production of one product to another with minimal stoppage time.³ An example of firms adopting flexibility in production techniques to deal with shifts in demand between models comes from the Japanese auto industry. Japanese auto manufacturers have been praised for their investment in flexible technologies, and part of

¹ Uncertainty exists for individual models which then translates into uncertainty about aggregate demand.

² See Kogut (1983).

³ This flexibility is called "mix-flexibility."

their present success has been attributed to their ability to exploit this flexibility.

While it is clear that having flexibility is desirable in the face of future uncertainty, investing in flexibility is a resource allocation decision. As with all resource allocation decisions, the crucial question is whether committing scarce resources to acquire certain types of flexibility will result in substantial increases in expected value of the organization. This paper fills a gap in the existing literature on flexibility by showing how static investment valuation techniques may be inadequate for the task of project valuation when costs are stochastic and MNEs can manage capacity utilization, and offers an adjustment to the traditional "net present value" (NPV) rule. Once we modify the investment rule, we show how the MNE's strategic decisions regarding the location of economic activity and the maintaining of excess capacity (and possibly even investment timing) are affected.

Pindyck (1991) demonstrates how a firm should value the option to invest when investment is irreversible and in other work (Pindyck (1988) and Pindyck and He (1991)) presents a methodology for valuing incremental capacity. The critical idea is that when demand/costs are stochastic, the firm has the option in every period to decide whether or not to use a unit of capacity. The firm acquires this portfolio of options when it invests in a unit of capacity. However, the key decision for the firm is the investment decision i.e. whether it should pay a sunk cost to acquire that unit of capacity today or else wait till some future period. From his work he is able to show that in the presence of stochastic demand (and/or units costs or production) firms may postpone investment rather than invest today.

While this view is acceptable for national firms, this approach fails to recognize that many firms are multinational. MNEs locate plants in a host of countries and have the ability to manage capacity utilization in every plant depending on the variability of local conditions and exchange rates. In this paper we concentrate our attention on valuing operational flexibility as it pertains to the MNE's ability to exploit its global spread to produce a substantial share of its output at lowest cost. We show that the important variable for a MNE is not the variability of domestic environments

considered in isolation, but instead the co-variability (or lack thereof) of unit costs of production in the different geographical regions in which the MNE has a factory.

Kogut and Kulatilaka (1991) show how a firm (MNE) located in more than one country can produce all the output at lowest cost. We believe that this is an overstatement, as MNEs are capacity constrained in the various locations, and hence may be able to only shift capacity utilization. In this paper we will first show how a MNE should value projects that provide the MNE with the flexibility to shift production. Thereafter, we use the rigorous model derived in Section III, and test it with hourly wage data from various countries. The simulations demonstrate that for U.S.-domiciled MNEs, the value of excess capacity as a percentage of the adjusted present value of cash flows in countries like Germany, the U.K. and Ireland is significant when compared to the fraction of excess capacity to total capacity. For projects in Canada, the value of excess capacity (flexibility) is less significant because cost increases in the U.S. and Canada seem to be strongly correlated. This conclusion will clearly affect the investment location (invest in the US or invest abroad) and capacity choice (expand capacity in the US or invest in excess capacity abroad) decisions of US-based MNEs.

Section I introduces a new approach by arguing that having operational flexibility is tantamount to holding a portfolio of real options. Therefore, we present a stylized scenario and discuss how options pricing techniques can be used to value this type of flexibility. Section II provides a review of related literatures and shows how this paper departs from previous work. In Section III we provide a rigorous method by which the value of operational flexibility can be estimated. In Section IV we perform simulations based on different parameter values to demonstrate the sensitivity of the value of operational flexibility to various variables, and the significance of the value of real/operational flexibility in different countries. Section V suggests extensions to this approach, and Section VI posits some implications and concludes.

Section I

We begin by providing two examples of the operational flexibility that will motivate our analysis. Consider a U.S.-based shoe manufacturer with a global market that has a factory in the U.S. and one in S.E. Asia. Should the cost of U.S. labor increase substantially because the firm is expected to make mandatory health insurance payments to its workers, management may scale back operations in the U.S. and expand operations abroad.⁴

Alternatively, consider a car manufacturer that has factories around the world that produces its car engines. If exchange rate changes make it more expensive to import these engines from Latin America and less expensive to import them from Europe, there may be a significant benefit to redistributing capacity utilization in favor of European locations. However, these strategies are feasible only if there is excess capacity in the foreign locations, and if the costs of switching are not excessive. While these examples may seem to be very simplistic, MNEs are aware of the benefits of shifting capacity utilization when faced with increased costs in a particular location. Management of Black and Decker for example, actively shift capacity utilization when exchange rates change to prevent an erosion of profit margins.⁵⁶

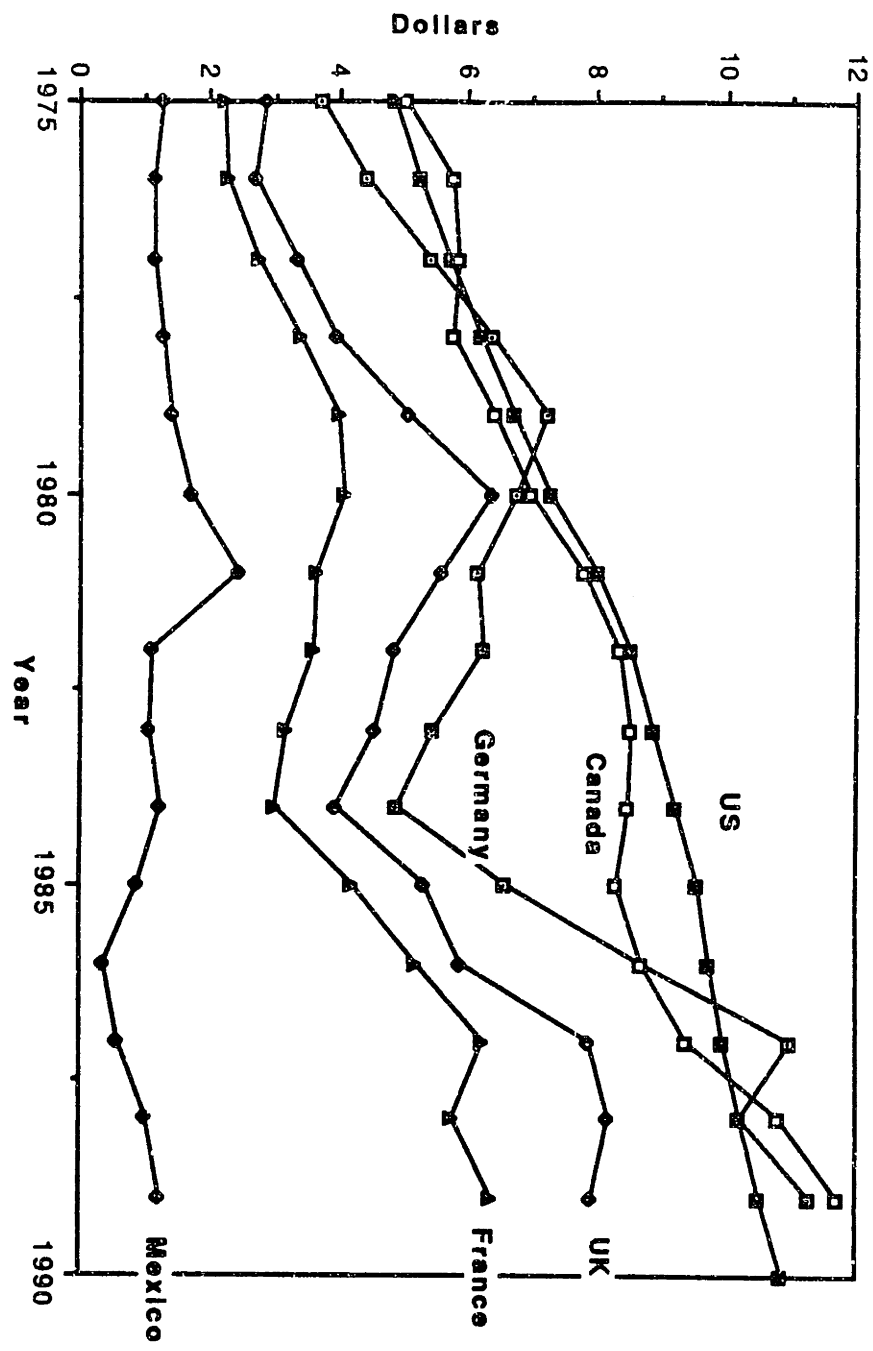
As the two hypothetical examples and Black and Decker's strategic decisions demonstrate, MNEs gain operational flexibility by diversifying their production locations. By virtue of their international spread, they, presumably, are able to access immobile inputs in different markets and produce goods at the lowest possible cost. The existence of these different entities in a host of countries creates a situation where management's evaluation of foreign projects must transcend the static Net Present Value (NPV) rule to incorporate the unique relationship that foreign investments have with existing investments. In this paper we first show that simple NPV rules that discount expected after-tax cash flows may not capture an essential

⁴ A similar example would be Zenith's movement of manufacturing operations to Mexico from its operations in Illinois, because of lower labor costs in Mexico.

⁵ See *Supplement to Corporate Finance*, June 1990, page 23.

⁶ Table 1 provides information on hourly wages in manufacturing (in \$) for countries in Europe and the American subcontinent. Graphs 1 and 1A plot the data. Refer to Appendix I for the data used to derive Table 1.

Graph 1 - Hourly Wages in Manufacturing (in Dollars)
(1975 - 1989)



Foreign Hourly Wage (\$) = Local Currency Hourly Wage * End of Year Exchange Rate

Graph 1A - Hourly Wages (\$) in France, Ireland, Spain and the UK

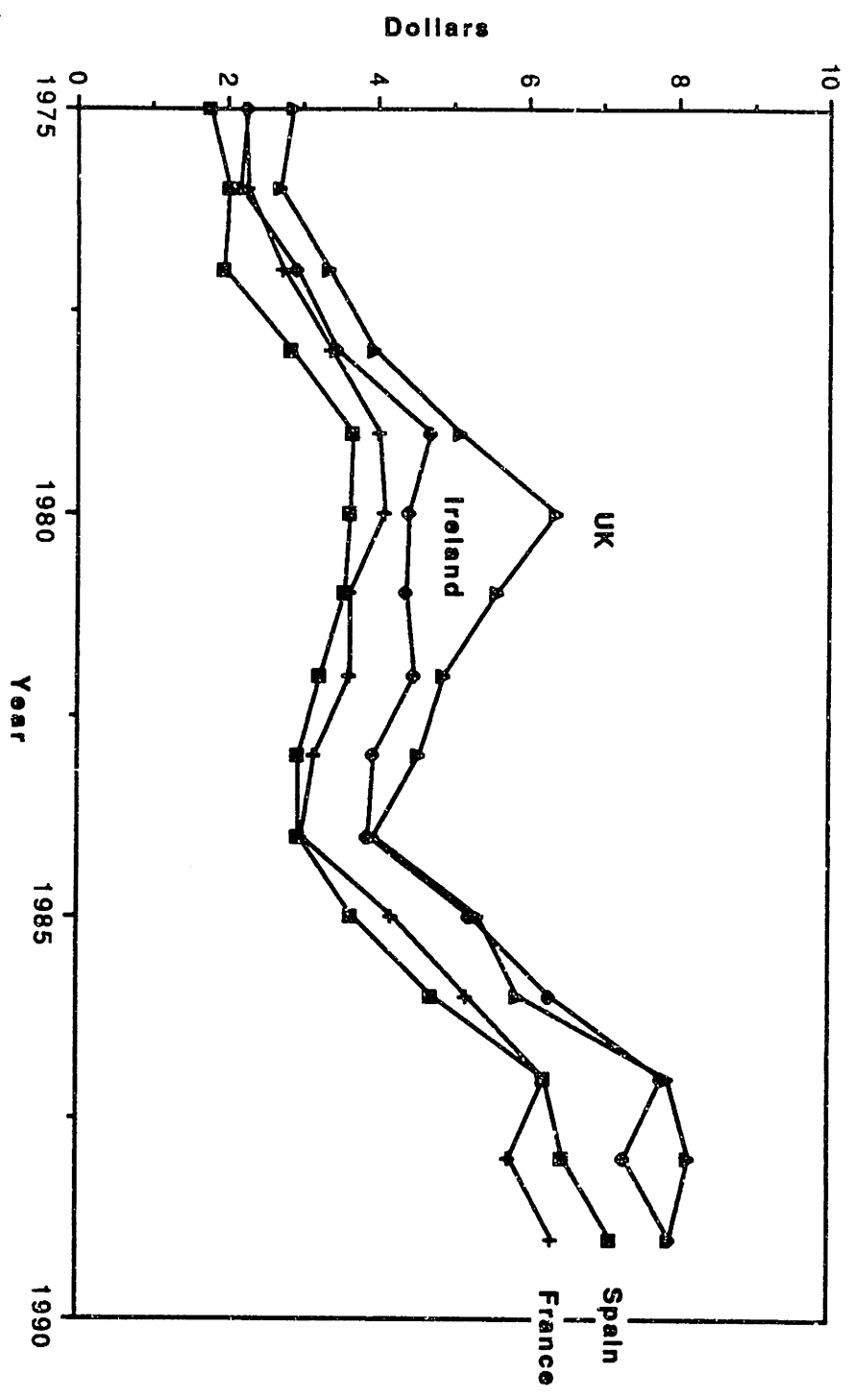


Table 1 - Hourly Wages in Manufacturing (in Dollars)

Year	Canada	France	Germany	Ireland	Mexico	Spain	U.K.	U.S.
1990	11.69	6.33	11.27	7.91	1.22	7.11	7.88	10.84
1989	10.77	5.76	10.20	7.30	0.98	6.47	8.15	10.49
1988	10.77	5.76	10.20	7.30	0.98	6.47	8.15	10.19
1987	9.38	6.23	10.97	7.79	0.55	6.23	7.85	9.91
1986	8.66	5.18	8.66	6.30	0.35	4.70	5.85	9.73
1985	8.29	4.17	6.57	5.21	0.85	3.66	5.33	9.54
1984	8.44	2.98	4.89	3.84	1.22	2.94	3.93	9.19
1983	8.49	3.13	5.43	3.92	1.03	2.92	4.54	8.83
1982	8.34	3.60	6.23	4.48	1.06	3.20	4.84	8.49
1981	7.76	3.62	6.15	4.36	2.42	3.55	5.58	7.99
1980	6.95	4.07	6.73	4.40	1.69	3.60	6.36	7.27
1979	6.39	3.99	7.20	4.69	1.40	3.66	5.07	6.7
1978	5.76	3.35	6.34	3.42	1.24	2.81	3.92	6.17
1977	5.84	2.72	5.39	2.90	1.13	1.94	3.33	5.68
1976	5.75	2.25	4.41	2.16	1.11	1.99	2.67	5.22
1975	5.00	2.21	3.73	2.24	1.24	1.76	2.85	4.83
Average Wage (\$)	7.83	3.97	6.94	4.73	1.17	3.77	5.21	8.02
Standard Dev. (\$)	1.92	1.35	2.33	1.86	0.47	1.66	1.77	1.91

Source : Yearbook of Labor Statistics (various issues) and World Currency Monitor Annual (1975-1989).

characteristic of multinational projects. Once we correct our valuation technique, we are able to compare between investing at home and investing in more than one location.

In order for the MNE to be able to switch production from one country to another, the MNE has to be willing to have idle capacity in the desired location. We structure the problem so that a national firm has experienced an increase in worldwide demand that can only be met by new investment.⁷ This new investment can be made either at home or in a foreign country. We assume that capacity expansion is lumpy and hence the firm is forced to invest in excess capacity. However, the key idea is that management may find it preferable to maintain excess capacity abroad, if input prices or exchange rates are volatile.

Management is expected to maximize the expected value of the firm. In evaluating domestic investments, management would have ensured that the present discounted value of all future earnings exceeded the cost of investment. However, if the firm has the opportunity in the future to produce abroad, at lower cost, some output that would have been produced at home, this benefit should be included in the valuation of the foreign project.

We assume that prices are fixed and demand is exogenously determined. Once the foreign investment is made, the increase in demand will be satisfied by production in the foreign location, and we can value the NPV of this aspect of the investment.⁸ In addition, the excess capacity abroad allows the firm to consider producing more output abroad if the local currency equivalent of producing abroad⁹ is less than the unit cost of production in the

⁷ Alternatively, we can structure the problem such that the firm is replacing existing capacity and has to decide between expanding capacity in existing locations and investing in capacity in new locations.

⁸ This is a relatively simple calculation. We will call this base NPV (abroad)

$$= \int_0^T (p - w^*) q e^{-rt} dt - I$$

where p = price, w^* = marginal cost, q = quantity, and I = sunk cost of investment.

⁹ Local currency equivalent = Unit costs abroad * exchange rate.

home country. The firm would not have been afforded this opportunity to lower costs if it had expanded capacity in the original location.

To value this flexibility we must make some assumptions about the volatility and time path of unit costs at home and the local currency equivalent of producing at home. The time path of the difference between the two costs is modeled as a Brownian Motion with no drift, to capture the volatile nature of the costs.¹⁰ In every future period, management will observe the unit costs and the exchange rates in the two countries and decide whether or not to exercise the option to shift capacity utilization abroad. The foreign project, in addition to servicing the increase in demand, provides the firm with an option in every period to utilize excess capacity to increase firm value.

If investments in capacity must exceed existing demand, then we are able to show that there is value to maintaining excess capacity in a foreign location. This value is derived from the fact that the sourcing of inputs has been diversified, and the firm can take advantage of changes in unit costs or exchange rates to lower the total cost of production. Therefore, a national firm that is considering capacity expansion should invest locally only if $NPV(\text{invest locally}) > \text{Adjusted NPV}(\text{abroad})$ where $\text{Adjusted NPV}(\text{abroad}) = \text{base NPV}(\text{abroad}) + \text{Portfolio of real options}$ that allow the firm to lower the total cost of production. If we value this portfolio correctly, it should equal the present discounted value of all expected future cost savings, given the stochastic process chosen and the exercise rule stated earlier.

Finally, once we modify the investment valuation rule, we can use the new rule to compare competing investment locations. It should be obvious that a correct comparison will involve comparing the Adjusted NPVs of these locations to capture the fact that they will contribute some value to the existing organization by satisfying the increase in demand and, in addition, in the case of a foreign location, through the optimal utilization of the excess capacity. In Section II we present a brief review of related work.

¹⁰ Refer to Graph 2 for a plot of the difference between hourly wages in the US and Canada, and in the US and Germany (1975-89). Data for this graph is provided in Table 2.

Graph 2
Difference in Hourly Wages in Manufacturing (\$)
(1975 - 1989)

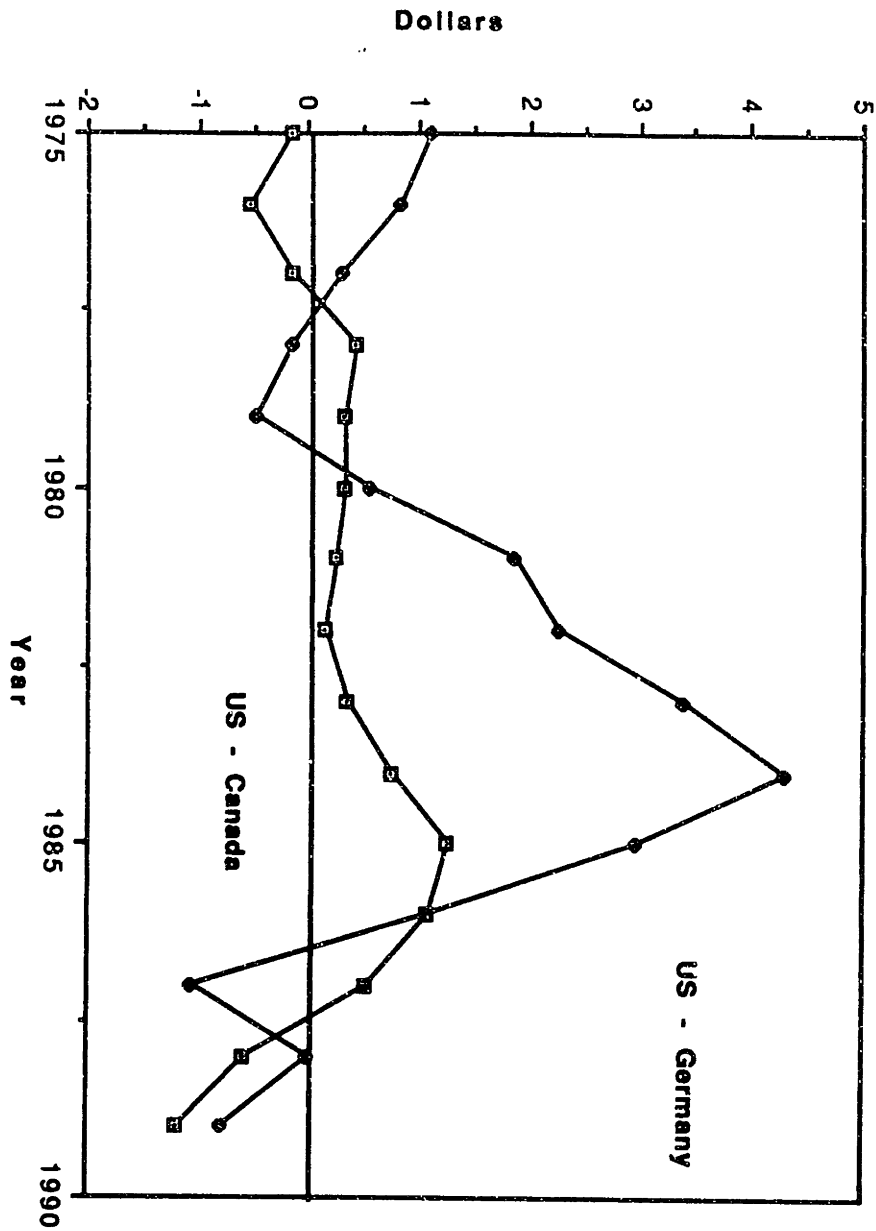


Table 2 - Difference between hourly wages in the US and other countries

Year	US-Canada	US-France	US-Germany	US-Ireland	US-Mexico	US-Spain	US-UK
1989	-1.20	4.16	-0.78	2.58	9.27	3.38	2.61
1988	-0.58	4.43	-0.01	2.89	9.21	3.72	2.04
1987	0.53	3.68	-1.06	2.12	9.36	3.68	2.06
1986	1.07	4.55	1.07	3.43	9.38	5.03	3.88
1985	1.25	5.37	2.97	4.33	8.69	5.86	4.21
1984	0.75	6.21	4.30	5.35	7.97	6.25	5.26
1983	0.34	5.70	3.40	4.91	7.80	5.91	4.29
1982	0.15	4.89	2.26	4.01	7.43	5.29	3.65
1981	0.23	4.37	1.84	3.63	5.57	4.44	2.41
1980	0.32	3.20	0.54	2.87	5.58	3.67	0.91
1979	0.31	2.71	-0.50	2.01	5.30	3.04	1.63
1978	0.41	2.82	-0.17	2.75	4.93	3.36	2.25
1977	-0.16	2.96	0.29	2.78	4.55	3.74	2.35
1976	-0.53	2.97	0.81	3.06	4.11	3.23	2.55
1975	-0.17	2.62	1.10	2.59	3.59	3.07	1.98
Average diff. in wages	0.18	4.04	1.07	3.29	6.85	4.25	2.81
Volatility (σ_w)	0.64	1.16	1.59	0.98	2.12	1.13	1.18

Section II

This paper is an integration of three related strands of analysis; namely, the literature on the correct valuation of foreign projects, the literature on the flexibility of MNEs, and the emerging literature on the option value of investment, when investment is irreversible.

Lessard (1978) has shown that NPV analyses, unless correctly done, may ignore the benefits that a foreign project provides.¹¹ When foreign projects are undertaken with subsidized financing and under favorable tax treatment, Lessard (1978) recommends that MNEs calculate an Adjusted Present Value (APV) for that foreign project. The APV approach posits that different facets of foreign investments like subsidized financing should be discounted at appropriate risk-adjusted discount rates, and that the present value of these subsidies should be added to the present discounted value of the after-tax cash flows.

In addition, Lessard and Paddock (1980), in a paper on the benefits of valuing international projects by components argue that there are three distinct components to a foreign project that can be readily identified. Projects produce cash flows that are fixed by contract (*debt equivalents*), respond closely to a set of underlying economic forces (*equity equivalents*), and "respond non-linearly to changes in some underlying cash flows or asset values"¹² (*option equivalents*). Kogut (1985) has emphasized that multinational firms have flexibility which permits them to hedge against the uncertainty over future exchange rates, competitive moves or government policy.¹³ Baldwin (1986) argues that MNEs have location, timing, technology (flexibility) and growth/staging options, and that management should identify, evaluate and exercise these options in an optimal fashion. While these papers capture the importance of flexibility of the multinational enterprise, they do not provide a methodology to value these options or show the extent to which traditional NPV analyses may fall short of capturing the true value of a foreign investment opportunity.

¹¹ See also Levi (Chapter 15), and Lessard and Shapiro (1983).

¹² page 11.

¹³ page 27.

An emerging literature attempts to value the option equivalents imbedded in certain domestic investments.¹⁴ For example, when future demand is uncertain, shutdown is costless and investment can be postponed, the NPV of investing today should not be taken in isolation, but instead has to be compared to the value of postponing the investment to a later date. While the option to shutdown is valuable, having the option to postpone investments may cause a firm to consider investing at a later date when the volatility of either demand or costs does not erode expected future profits.

Contingent claims pricing methods have been used by Trigeorgis and Mason (1987) to value managerial flexibility, and by Triantis and Hodder (1990) to value flexible production systems which allow firms to switch their output mix over time.¹⁵ Recent work by Kogut and Kulatilaka (1991) integrates the work on flexibility and the option equivalents in foreign investments. Their paper addresses issues raised in this paper, but their emphasis is on demonstrating how the sequential process of investment overseas affects the evaluation of all investments that take place after the initial foreign direct investment. They show how the initial investment provides the organization with growth opportunities and then demonstrate the benefit of maintaining operational flexibility when exchange rates are volatile. While this paper focuses on managing capacity utilization, Kogut and Kulitalaka (1991) model the MNE as producing all of the output in the lowest cost location, and without any capacity constraints.

Projects in several countries provide MNEs with a productive presence in these countries. When business environments around the world are changing constantly, this diversification of production and/or sourcing of inputs is extremely valuable. The key contribution of this paper is to focus attention on the correct valuation of foreign projects under these circumstances, and to suggest that simple NPV analyses should be complemented with a valuation of the real options that the foreign entity

¹⁴ Pindyck (1988) provides a review of this literature and Brealey and Myers (4th edition)-Ch. 21 outlines a few situations where options pricing theory is useful for valuing certain aspects of real investments.

¹⁵ We had referred to this type of flexibility as "mix flexibility."

provides. Furthermore, we emphasize that multinational firms do not close plants and move to another location, but instead, are capacity constrained and can only manage capacity utilization at the margin.

In the next section we formalize the analysis by providing a precise model that is based on the discussion above.

Section III

When faced with input price volatility (in domestic markets) management must decide whether to invest domestically today, wait to invest locally in the future or else invest abroad. In this section we will only present a method to value expanding capacity at home and foreign investments, and point the reader to the Appendix for a discussion on the optimal timing of investment.¹⁶

We present below a simple model to show how real flexibility can be valued using option pricing theory, and how this should be used in arriving at a correct valuation of a foreign investment opportunity.

Assumptions :

- A.1 A firm in country A has capacity to produce x units of output per period from a single factory in country A. The factory can produce output for an infinite number of periods.
- A.2 Demand has increased to $x+d$ units of output per period and is not expected to increase in the future.¹⁷
- A.3 Capacity expansion is lumpy¹⁸ and the firm can only invest in capacity to produce x more units/period in another factory, either locally, or abroad, say in country B.
- A.4 Goal of management is to maximize the value of the firm.
- A.5. Assume that the output is sold on the world market at price p , which is given by the market. (The goal of the firm can now be reduced to cost minimization instead.)
- A.6 Wages in country B are fixed and equal to w^* in every period, where $p \gg w^*$; $p - w^* = b$.¹⁹

¹⁶ Once we show how to correctly value foreign projects, we combine this result with the results of Pindyck (1988) to discuss the optimal timing of investments. See Appendix.

¹⁷ For example, we could assume that GM has to manufacture a fixed number of car engines and is considering distributing manufacturing facilities around the world. I thank Prof. Myers for this example.

¹⁸ We will address this assumption later in the paper.

¹⁹ We ignore all issues arising from exchange rate fluctuations for simplicity, but this is not an egregious assumption. We could consider the home currency equivalent of the foreign unit labor cost = w^* , where $w^* = w^B e$ (e = exchange rate).

- A.7 Wages in country A, w^A , fluctuate randomly and w^A may be greater than or less than w^* , and greater than or less than the price of output p .
- A.8 Define $\Delta = w^A(t) - w^*$ and assume that variations in Δ can be captured by the following stochastic process :
- $$d\Delta = \sigma_{\omega} dz \quad (1)$$
- where $dz = \varepsilon(t)(dt)^{1/2}$ is the increment on standard Brownian motion. $\varepsilon(t)$ has zero mean and unit standard deviation. $E[dz] = 0$ and $E[(dz)^2] = dt$. σ_{ω} is the instantaneous standard deviation.²⁰
- A.9 Assume that the changes in wages have zero beta (uncorrelated with the market portfolio).
- A.10 Production technology is such that a single worker produces one unit of output per period i.e. one unit costs w^A if produced in A or w^* if produced in B.
- A.11 There is a sunk cost of investment = I , and investment is irreversible.
- A.12 Production can be switched from one factory to another costlessly and with no time lag.
- A.13 We will ignore transportation costs, and all tax, tariff and foreign exchange issues. (Refer to A.6 and accompanying footnote)
- A.14 The firm is risk-neutral.
- A.15 Let r be the real risk-free interest rate and assume that r does not change.²¹

If the firm expands capacity in country A then its costs in every period are $(x+d)w^A$ as long as the unit labor cost is below p . If w^A exceeds p , the firm may want to shut down, unless it is trying to protect market share. However, if the firm invests in country B to complement its original investment in A, then costs are equal to $\min[xw^A + dw^*, dw^A + xw^*]$. Therefore, a simple NPV analysis to evaluate the investment in B that assumed that the plant in B

²⁰ This definition does not preclude the possibility that wages in country B can fluctuate, but for the sake of simplifying the discussion we will assume that w^* remains unchanged.

²¹ Another business climate that we can consider is one where the aggregate demand of the firm is split 50-50 between the foreign and home markets. The decision for the firm is whether to invest all its capacity in one location; invest in both countries, but use each facility to satisfy local demand; and invest in both countries and use both factories to ensure the global optimum.

would produce only one unit of output would underestimate the true value of the foreign investment. A static NPV analysis might assume that the extra unit of capacity will be left unused at all times, given insufficient demand, whereas the approach we present below takes into account the benefit of maintaining that extra unit of capacity when unit costs in one environment are more volatile than they are in another.

If we assume that shutdown is costless and that the firm will not produce output in A when the wage rate in A exceeds the price of output, we can find the value of flexibility.

$$\text{Define } b = p - w^* \quad (2)$$

$$\text{Define } w^A = w^* + \Delta \quad (3)$$

$$\text{This implies that } p - w^A = b - \Delta \quad (4)$$

Also, from (1), $d\Delta = \sigma_\omega dz$.

$$\text{Now the cash flows generated by a national firm} = (x+d)(p - w^A)^+ \quad (5)$$

$$\text{where we define } (p - w^A)^+ = \max[p - w^A, 0] \quad (6)$$

For simplicity assume that $x = 2$ and $d = 1$.²²

Therefore, if the firm expands capacity at home, the cash flows generated by a national firm in every period (ignoring time subscripts)

$$= 3(p - w^A)^+ = 3(b - \Delta)^+ \quad (5')$$

since expanding capacity at home will generate additional cash flows

$$= (b - \Delta)^+ \text{ in every period.} \quad (6')$$

Define $N(\Delta)$ = expected present value of a unit of capacity in the home country. From (6') we know that

$$N(\Delta) = E_t \left[\int_{t=0}^{\infty} e^{-rt} [(b - \Delta_t)^+] dt \mid \Delta_0 = \Delta \right]$$

²² In Appendix II we express the cash flows in terms of x and d and also show the results when we substitute for their values assumed above.

$$\text{or } N(\Delta) = \max_{j=0/1} E_t \left[\int_{t=0}^{\infty} e^{-rt} [j(b - \Delta_t)] dt \mid \Delta_0 = \Delta \right]$$

given that Δ follows the stochastic process specified in (1). We show in the Appendix that $N(\Delta) = N(b, \Delta)$, and under the appropriate boundary, smoothness and continuity conditions

$$N(\Delta) = \frac{1}{2rg} e^{(-b+\Delta)g} + \frac{b-\Delta}{r} \quad \text{when } \Delta < b \quad (7a)$$

$$= \frac{1}{2rg} e^{(b-\Delta)g} \quad \text{when } \Delta > b \quad (7b)$$

A brief explanation of (7a) and (7b) is in order. Let us examine (7a) first. When $\Delta < b$, this implies that $p > w^A$ and the firm is producing the additional unit of output at home. If the wage in A were never to change the present value of all future earnings = $\frac{b-\Delta}{r}$. However, should the wage in A

rise above p , the firm will shutdown and the value of this option =

$\frac{1}{2rg} e^{(-b+\Delta)g}$. (7b) states that if the wage in A is higher than p , the firm is not producing output, but has the option to produce the additional unit of output when the wage rate in A falls. The value of the option to restart production = $\frac{1}{2rg} e^{(b-\Delta)g}$.

On the other hand, determining the cash flows generated by a MNE in every period is an interesting problem. The MNE will produce one unit abroad, produce one in A if the wage in A is below p , and produce the third in the lowest cost location... This approach allows the MNE to minimize the labor costs of producing three units of output. We can express these cash flows, ignoring time subscripts, in equation (8a)

$$\text{Cash Flow for the MNE} = (p - w^A)^+ + b + p - \min(w^A, w^*) \quad (8a)$$

$$= (b - \Delta)^+ + b + p - (w^* + \min(\Delta, 0)) \quad (8b)$$

$$= 2b + (b - \Delta)^+ - \min(\Delta, 0) \quad (8c)$$

$$= 2b + (b - \Delta)^+ + \max(-\Delta, 0) \quad (8d)$$

$$= 2b + (b - \Delta)^+ + (-\Delta)^+ \quad (9)$$

Notice though, that the incremental cash flows of the foreign project = cash flows (CFs) provided by a MNE less the cash flows that existing investments in the home country will provide. From (5'), (6') and (9), we find that the incremental CFs from the foreign project

$$= 2b + (b - \Delta)^+ + (-\Delta)^+ - 2(b - \Delta)^+ \quad (10a)$$

$$= 2b - (b - \Delta)^+ + (-\Delta)^+ \quad (10b)$$

Equation (10b) will be crucial for our calculation of operational flexibility.

To value flexibility we determine the cash flows associated with using the excess capacity in an optimal fashion. Therefore, we take the incremental cash flow of the foreign project, and deduct the cash flows from producing one unit of output abroad. This calculation provides us with the cash flows that the foreign project will generate (from the unit of excess capacity) over and above satisfying the increase in demand. From (10b) we know that the incremental cash flow provided by the foreign project = $2b - (b - \Delta)^+ + (-\Delta)^+$.

Therefore, the cash flows associated with flexibility

$$= 2b - (b - \Delta)^+ + (-\Delta)^+ - b \quad (11a)$$

because b is the guaranteed cash flow produced by the foreign investment from satisfying the unit increase in demand.

$$\text{Cash flows associated with flexibility} = b - (b - \Delta)^+ + (-\Delta)^+ \quad (11b)$$

Define $R(\Delta)$ = value of operational/real flexibility = expected present value of all cash flows that the foreign project generates through the optimal usage of excess capacity. Then from (11b) we know that

$$R(\Delta) = E_t \left[\int_{t=0}^{\infty} e^{-rt} [b - (b - \Delta_t)^+ + (-\Delta_t)^+] dt \mid \Delta_0 = \Delta \right] \quad (12)$$

We provide a detailed proof in the Appendix, but with appropriate boundary, smoothness and continuity conditions it can be shown that

$$R(\Delta) = \frac{b}{r} - N(b, \Delta) + N(0, \Delta)$$

$$= \frac{b}{r} - \frac{1}{2rg} e^{(-b+\Delta)g} - \frac{b-\Delta}{r} + \frac{1}{2rg} e^{(\Delta)g} + \frac{-\Delta}{r} \quad \text{when } \Delta < 0 \quad (13a)$$

$$= \frac{b}{r} - \frac{1}{2rg} e^{(-b+\Delta)g} - \frac{b-\Delta}{r} + \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } 0 \leq \Delta \leq b \quad (13b)$$

$$= \frac{b}{r} - \frac{1}{2rg} e^{(b-\Delta)g} + \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } \Delta \geq b \quad (13c)$$

These equations can be reduced to the following

$$= \frac{1}{2rg} e^{(\Delta)g} - \frac{1}{2rg} e^{(-b+\Delta)g} \quad \text{when } \Delta < 0 \quad (13a)$$

$$= \frac{\Delta}{r} - \frac{1}{2rg} e^{(-b+\Delta)g} + \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } 0 \leq \Delta \leq b \quad (13b)$$

$$= \frac{b}{r} - \frac{1}{2rg} e^{(b-\Delta)g} + \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } \Delta \geq b \quad (13c)$$

Before we provide a detailed interpretation for (13a), (13b) and (13c) we discuss why we have three regions over which $R(\Delta)$ is defined. The value of flexibility will depend on the value of w^A relative to the foreign wage and the price of output. When $\Delta < 0$, then $w^A < w^* < p$. When $0 \leq \Delta \leq b$, $w^* \leq w^A \leq p$, and when $\Delta > b$, then w^A is greater than p .

We now provide a brief explanation for the value of $R(\Delta)$ over the three regions. From (13a) we conclude that when $\Delta < 0$, the wage rate at home is less than the wage rate in B, and even though the firm is not using the excess capacity abroad, it has the option to do so in the future. However, if w^A should rise above the price of output, the maximum saving afforded by the foreign investment is $= \$b$ in every period. When $0 \leq \Delta \leq b$, then the wage in A is above the foreign wage, but below p . We find from (13b) that if the wage in A were never to change the present value of all cost savings provided by

excess capacity abroad = $\frac{\Delta}{r}$. However, if the wage rate in A should fall below the wage rate abroad, the firm will want to switch production back to the home country, and this is a valuable option. In addition, if the wage rate in A rises above p , the maximum cost saving from producing the third unit of output abroad in every period = $\$b$. Equation (13c) considers the case where w^A is greater than p and the analysis is similar to that described above for equation (13b); namely, that the firm is presently earning $\$b$ in every period, and will continue to do so if the wage in A never changes. However, if w^A falls, then the firm would like to change its utilization of capacity depending on how low w^A falls.²³

From the discussion above it is quite obvious that the value of the foreign investment is more complex than a simple NPV calculation of guaranteed profits.²⁴ Instead, as proposed by Lessard and Paddock (1980), the value of a project is the value of the components that are contractual, non-contractual and those that are like options, and hence the value =

$$\int_{t=0}^{\infty} e^{-rt} (p-w^*) dt - I + R(\Delta) . \quad (14)$$

²³ If we had chosen to let the maximum cost-saving be unbounded, rather than bounded by b , we would have overstated the value of operational flexibility. This is similar to a binomial distribution, and in such a situation

$$R(\Delta) = E\left[\int_{t=0}^{\infty} e^{-rt} [(\Delta_t)^+] dt \mid \Delta_0 = \Delta \right]$$

²⁴ If we wanted to compare the value of a national firm to one that is multinational, we would compare $3N(\Delta)$ (adjusted PV of producing 3 units at home) to $M(\Delta)$ (where $M(\Delta)$ is the value of a MNE, and we derived this in the Appendix), ignoring the costs of investment. It would be interesting to see the conditions under which being multinational is preferred to being national i.e. the values of Δ , and σ for which this would be true.

Section IV

Section IV is divided into two sub-sections : A and B. In Section IV A we conduct sensitivity analyses to determine the impact of various variables on the value of operational flexibility. We show how the investment analysis should be conducted when a foreign investment not only meets increases in demand, but also allows the MNE to produce a bulk of total production at the lowest (worldwide) marginal cost. We also show how an exclusion of the value of flexibility can lead to an incorrect rejection of a foreign project. Section IV B extends this analysis to a related problem. We compare competing investment opportunities in different countries, including the home country. We assume that these countries are similar in every respect except that the domestic currency equivalent of unit costs and the volatility of cost savings (degree of correlation of the foreign country with the home country) are different. In addition to evaluating the investment location decision we attempt to show how capacity choice decisions might be impacted when we recognize that excess capacity is valuable if it is in a foreign location.

Section IV A

We simulate the effect of various parameters on the value of the portfolio of options to determine how $R(\Delta)$ is impacted by changes in the interest rate, cost-saving and the volatility of cost-saving. We use the data that we have for the United States and Germany, and arbitrarily select values for p and r to illuminate the value of $R(\Delta)$ under different conditions.²⁵ To make the illustration more interesting we utilize the data for 1989 since Germany has a higher unit cost than the U.S. ($w^* > w^A$). From Table 2 we find that $\sigma_\omega = 1.59$ and we assume that this measure of volatility is appropriate as of 1989. Through this process we try to illuminate the trade-off that MNEs need to consider between experiencing lower costs of production today versus having access to lower costs of production in the future. We refer the reader to Table 3.

²⁵ While our valuation technique in the previous section was based on real rates and real wages, in this analysis we use nominal variables. Values for Germany and the US were selected from Tables 1 and 2.

Table 3 - Valuing Real Flexibility in Germany

Assume that the sunk cost of investment (I) = 80
 Assume that the price of output (p) = \$15.

	Int. Rate r (%)	Std. Dev. σ_w	Wage Rate in the US	Wage Rate in Germany	$\Delta =$ ($w_{US} - w^*$)	R(Δ)	Simple NPV in Germany = $(p-w)/r-I$ (7)	Adj. NPV = $(6) + (7)$ (8)
(1)	6	1.59	10.49	11.27	-0.78	17.95	-17.83	0.12
(2)	6.5	1.59	10.49	11.27	-0.78	16.60	-22.62	-6.02
(3)	7	1.59	10.49	11.27	-0.78	14.76	-26.71	-11.95
(4)	6	1.3	10.49	11.27	-0.78	16.00	-17.83	-1.83
(5)	6	1.4	10.49	11.27	-0.78	17.15	-17.83	-0.68
(6)	6	1.5	10.49	11.27	-0.78	18.22	-17.83	0.39
(7)	6	1.59	9.5	11.27	-1.77	14.47	-17.83	-3.36
(8)	6	1.59	10.5	11.27	-0.77	17.99	-17.83	0.16
(9)	6	1.59	11.5	11.27	0.23	22.37	-17.83	4.54

In this simple model, $R(\Delta)$ is the value of the extra unit of capacity in the foreign location. As can be seen from the table above, higher interest rates and lower volatility reduce the value of the portfolio of options. If the real interest rate is high, then the present value of future cost-saving is low (rows 1-3, column 6). However, increased volatility in cost-saving raises the value of excess capacity (rows 4-6, column 6). Values for σ_ω capture the degree to which domestic wages and the dollar equivalent of foreign wages are positively correlated. The higher the σ_ω , the lower the positive correlation, which in turn implies that there is a higher probability that the firm will exercise the option to utilize the extra unit of capacity in the foreign location. Notice further that in this model, $R(\Delta)$ is strictly increasing in Δ (rows 7-9, column 6). As the hourly wage in the U.S. (w^{US}) approaches w^* (hourly wage in Germany) there is a higher probability that w^{US} will be greater than w^* and that excess capacity in Germany will be utilized by the firm.

Incorporating this valuation of excess capacity into the NPV analysis could change the final decision of the firm. In a number of instances, a simple NPV analysis would suggest that the investment in Germany was not profitable to domestic and foreign investors. However, on including the value of $R(\Delta)$ in the calculations we have the possibility that the investment could be attractive to a firm domiciled in the U.S. (e.g. rows 6, 8 and 9).

Section IV B

In a domestic setting, expectations of increased volatility (higher σ) in input prices could lead firms to postpone investment decisions, either of entire plants or of incremental capacity in a plant, as suggested by Pindyck and He (1990). While higher volatility raises the value of the option to wait, it may also increase the value of the option to invest abroad. Therefore, a firm with international business could find this situation to be conducive to investing abroad and exploiting the ability to source in the cheapest markets.

Usually when a firm considers a foreign investment to service a global market, it has to decide between a number of sites in different countries. In this section, we compare the value, to a U.S.-based MNE, of investments in Germany, Canada, the U.K. and Ireland in an attempt to show the contribution to firm value of investment sites that have different unit costs (w^i) and different volatilities of cost-saving (σ_ω).²⁶ We are making an implicit assumption that the average wage is the same in the countries. Table 4 provides summary statistics for the wage data used in these simulations, and from Table 4 we know that this is not the case. However, we show below that this will not affect our comparative results.

For these comparisons we assume that $r = 6\%$, and $p = 15$. For simplicity, we first compare the expected present value of the cash flows in all locations and hence set $I = 0$. We will return to the issue of the cost of investment later on, as this will affect the NPV of the investments. Moreover, we will try to discuss how investment location decisions are impacted when the cost of expanding capacity in the US is lower than the cost of installing a new plant in a foreign country.

²⁶ This comparison is a first approximation because we had assumed in the model that the foreign environment was static. Therefore, to be exact we must use the measure of volatility that we derive from wages in the U.S (σ_{US}). However, we compensate by using the values of σ_ω from Table 2 for each of the countries, rather than using σ_{US} as the measure of volatility for all countries. If were to use σ_{US} as the measure of volatility of cost-saving for all the countries, the comparison would be meaningless, but valuing flexibility would still be possible for the individual countries.

Table 4 - Summary Statistics for Wage Data (1975-1989)

	Germany	Canada	The U.K.	Ireland	France	U.S.
1) Hourly Wage in Country (\$) in 1987	10.97	9.38	7.85	7.79	6.23	9.91
2) Average Hourly Wage (\$)	6.94	7.83	5.21	4.73	3.97	8.02
3) $\sigma(w_s^i)$	2.33	1.92	1.77	1.86	1.35	1.91
4) $\sigma(w_{us} - w^i)$	1.59	0.64	1.18	0.98	1.16	N.A.

Table 5A - Comparing investment locations for 1985 ($w^{us} = \$9.54$)

Price of Output (p) = \$15

Nominal Interest Rate = 6%

	US (Invest in 1 unit)	Germany (Invest in 2 units)	Canada (Invest in 2 units)	The U.K. (Invest in 2 units)	Ireland (Invest in 2 units)
1) Wage in Country (\$)	9.54	6.57	8.29	5.33	5.21
2) σ	1.91	1.59	0.64	1.18	0.98
3) Static PV = $(p-w)/r$	91.00	140.5	111.83	161.16	163.16
4) $R(\Delta)$: Value of Excess Capacity		57.89	27.86	72.7	73.85
5) Adjusted Present Value	124.11	198.39	139.69	233.87	237.01
6) $R(\Delta)$ as a % of the Adj. Present Value = $(4)/(5)$		29%	19.9%	31%	31%

For Tables 5A-E, Excess Capacity = 25% of Total Capacity

Table 5B - Comparing investment locations for 1986 ($w_{us} = \$9.73$)

Price of Output (p) = \$15

Nominal Interest Rate = 6%

	US (Invest in 1 unit)	Germany (Invest in 2 units)	Canada (Invest in 2 units)	The U.K. (Invest in 2 units)	Ireland (Invest in 2 units)
1) Wage in Country (\$)	9.73	8.66	8.66	5.85	6.30
2) σ	1.91	1.59	0.64	1.18	0.98
3) Static PV = $(p-w)/r$	87.83	105.67	105.67	152.50	145.00
4) R(Δ) : Value of Excess Capacity		36.00	25.57	67.71	60.52
5) Adjusted Present Value	105.50	141.67	131.24	220.21	205.52
6) R(Δ) as a % of the Adj. Present Value = (4)/(5)		25%	19.5%	31%	29%

Table 5C - Comparing investment locations for 1987 ($w_{us} = \$9.91$)

Price of Output (p) = \$15

Nominal Interest Rate = 6%

	US (Invest in 1 unit)	Germany (Invest in 2 units)	Canada (Invest in 2 units)	The U.K. (Invest in 2 units)	Ireland (Invest in 2 units)
1) Wage in Country (\$)	9.91	10.97	9.38	7.85	7.79
2) σ	1.91	1.59	0.64	1.18	0.98
3) Static PV = $(p-w)/r$	84.83	67.17	93.67	119.16	120.17
4) $R(\Delta)$: Value of Excess Capacity		17.74	19.41	43.47	42.57
5) Adjusted Present Value = (3) + (4)	118.69	84.91	113.08	162.63	162.74
6) $R(\Delta)$ as a % of the Adj. Present Value = (4)/(5)		21%	17%	27%	26%

Table 5D - Comparing investment locations for 1988 ($w^{US} = \$10.19$)

Price of Output (p) = \$15

Nominal Interest Rate = 6%

	US (Invest in 1 unit)	Germany (Invest in 2 units)	Canada (Invest in 2 units)	The U.K. (Invest in 2 units)	Ireland (Invest in 2 units)
1) Wage in Country (\$)	10.19	10.20	10.77	8.15	7.30
2) σ	1.91	1.59	0.64	1.18	0.98
3) Static PV = $(p-w)/r$	80.17	80.00	70.50	114.17	128.33
4) R(Δ) : Value of Excess Capacity		24.75	10.27	42.68	52.35
5) Adjusted Present Value = (3) + (4)	114.60	104.75	80.77	156.85	180.68
6) R(Δ) as a % of the Adj. Present Value = (4)/(5)		24%	13%	27%	29%

Table 5E - Comparing investment locations for 1989 ($w_{US} = \$10.49$)

Price of Output (p) = \$15

Nominal Interest Rate = 6%

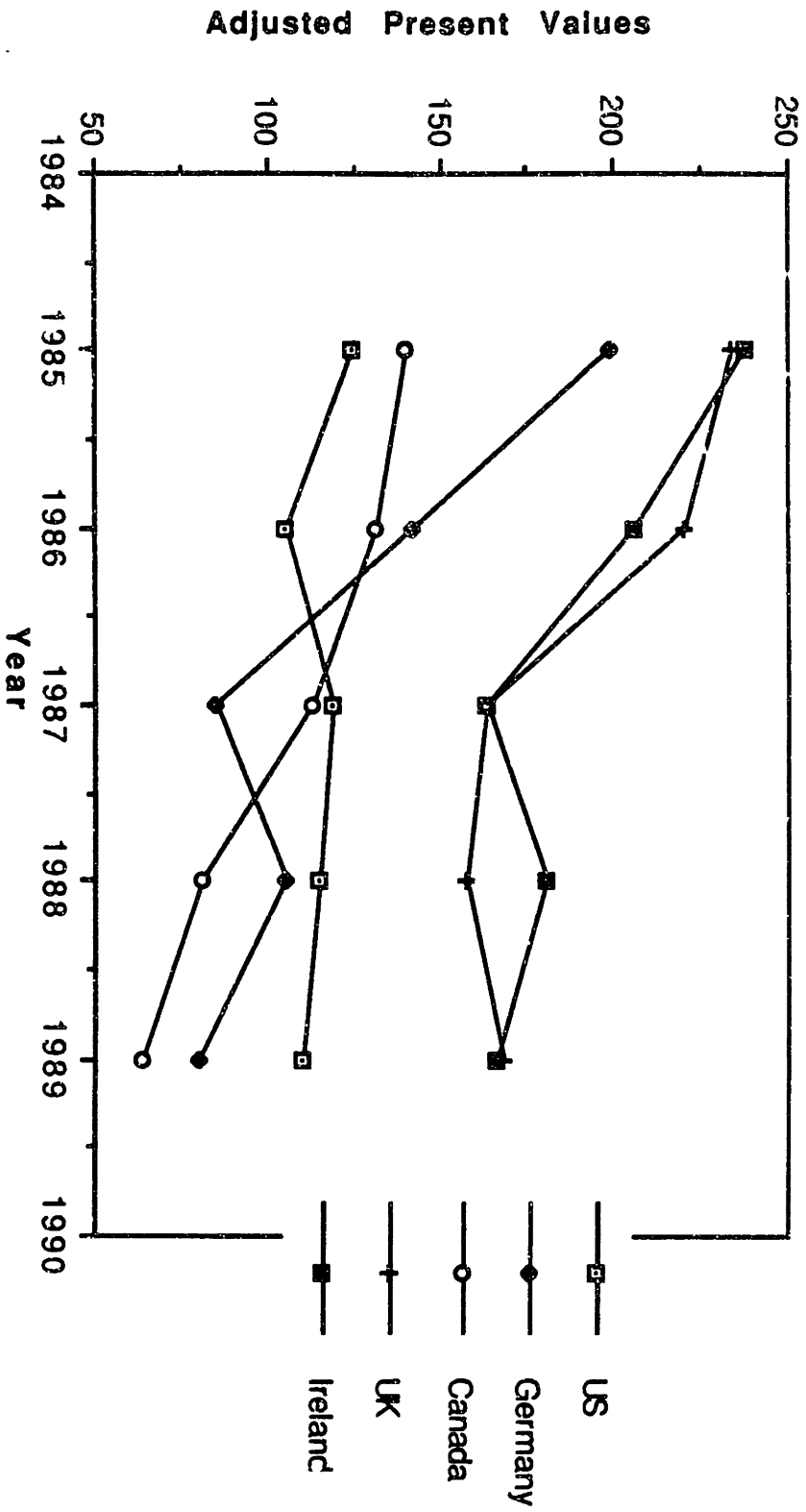
	US (Invest in 1 unit)	Germany (Invest in 2 units)	Canada (Invest in 2 units)	The U.K. (Invest in 2 units)	Ireland (Invest in 2 units)
1) Wage in Country (\$)	10.49	11.27	11.69	7.88	7.91
2) σ	1.91	1.59	0.64	1.18	0.98
3) Static PV = $(p-w)/r$	75.17	62.17	55.17	118.67	118.17
4) $R(\Delta)$: Value of Excess Capacity		18.01	8.14	49.14	47.68
5) Adjusted Present Value = (3) + (4)	110.22	80.18	63.30	167.81	165.85
6) $R(\Delta)$ as a % of the Adj. Present Value = (4)/(5)		22%	13%	29%	29%

In Tables 5A, B, C, D and E we compare the value of investments in the above mentioned countries and the US for the years 1985-89. The difference between an investment in the US and one abroad is that the foreign investment provides two units of capacity, while the investment in the US (essentially) increases total capacity by only one unit. If we only look at the foreign countries, then it is clear from Tables 5A-E that the lowest wage country is also the country with the highest adjusted present values (PV).

Two interesting conclusions can be derived from comparing (i) Germany to Canada and (ii) Ireland to the UK. If we look at the attractiveness of the investments in Germany and Canada (See Table 5B) in 1986, when the hourly wages (in dollars) in the two countries are the same, it is clear that the higher volatility in Germany (1.59 as opposed to 0.64 in Canada) makes the German opportunity more attractive. This result follows because German hourly wages (in dollars) are less strongly correlated with US hourly wages than Canadian hourly wages (in dollars). Therefore, investing in Germany provides greater diversification benefits to a US-based MNE than investing in Canada, and will be more valuable especially when the German dollar costs are less than or equal to Canadian costs.

If we compare Ireland and the United Kingdom for the year 1987, we once again get interesting results. While the hourly wage in Ireland (\$7.79) is less than the hourly wage in the U.K (\$7.85), the higher volatility of cost-saving of the U.K. investment leads to a situation where the investment in the UK has a marginally lower adjusted PV (\$162.63) than the Irish investment (\$162.74). This would indicate that the higher costs of production in any one location may not be a sufficient reason for the disqualification of that location, if there are benefits to be captured from diversifying the sourcing of inputs. Moreover, for whatever reason (e.g. relatively similar macro-economic policies), except for 1988, the adjusted present values of producing in Ireland and the UK are extremely close to one another. Since these two countries present identical investment opportunities (other things equal), in deciding between the two countries we may want to take into consideration the fact that the average dollar-equivalent wage in Ireland is lower than the average dollar-equivalent wage in the U.K.

Graph 3 - Comparing Investment Locations (1985-1989)



US = 1 Unit of Capacity; Foreign Locations = 2 Units of Capacity

While the previous analysis suggests that MNEs should diversify across currency areas, rather than within currency areas (Germany vs. Canada), and further may be relatively indifferent between countries in the same currency area (Ireland and UK), we have not compared investing abroad to expanding capacity in the US. As Graph 3 and Tables 5A-E demonstrate, in 1985 and 1986, US-based MNEs might have been willing to pay substantially more to invest in Germany, Ireland and the UK than expand capacity at home. For example, in 1985, if the sunk cost of expanding capacity in the US = \$100 (adjusted NPV = \$24.11), a US-based MNE would have found an investment in Germany to be more attractive if the cost of investing in Germany was less than \$174 (adjusted NPV = \$24.39 if $I = \$174$); and investing in excess capacity in the UK and Ireland to be more attractive if the sunk cost of investing in these countries was \$200 (adjusted NPV being approximately \$33).²⁷ However, the subsequent depreciation of the dollar has led to a sharp increase in the cost of producing in Germany (in dollars) in the last few years, and hence US-based firms will be willing to pay more to invest in only the UK and Ireland.²⁸

One last observation can be made from these tables. While excess capacity = 25% of total capacity in all locations, the value of excess capacity as a proportion of the adjusted PV varies across the countries. We find that including the value of flexibility is more important for projects where the measure of σ is high (low degree of correlation with the US), indicating that the company is investing in a diversified input sourcing program. The value of operational flexibility (i.e. the value of excess capacity) is more significant for projects in Germany and the U.K. for U.S.-domiciled MNEs than it may be for projects in Canada. This result follows because of the high correlation between wages in Canada and the U.S., and hence maintaining excess capacity in Canada may be sub-optimal.

²⁷ The wage in the US = \$9.54; UK = \$5.33; and Ireland = \$5.21.

²⁸ From Table 5E, we find that in 1989, the difference between the adjusted present value of investing in the UK (or Ireland) and the US is \$55. Therefore, a US-based MNE will invest in capacity in the UK and/or Ireland only if the cost of investing abroad is at most \$50 more than expanding capacity in the US.

To conclude this section, we can see that it is clear from these comparisons that if the present cost of producing in country B is higher than the present cost of producing in C, the firm is going to invest in B only if $\sigma_{\omega}(w^A - w^B)$ is significantly higher than $\sigma_{\omega}(w^A - w^C)$. Therefore, while there is some value to holding excess capacity when firms have operational flexibility, management will invest in a relatively high cost country only if the benefits to diversification of production promise significant cost saving in the future. Furthermore, for U.S.-based MNEs, maintaining excess capacity in Europe may be more attractive than maintaining excess capacity in Canada, and firms may be willing to pay more to invest in these countries than to expand capacity in the US.

Section V

With respect to caveats to the model presented above we can segment them into two categories; namely, those that are specific to the mathematical techniques employed and those that relate to the business environment assumed.

The portfolio of options will take on different values if we assume different stochastic processes.²⁹ In addition, if we are extremely rigid with the selection of the boundary conditions we may be forced to solve for $R(\Delta)$ numerically. In defense of the methodology used, the model is designed to capture the basic notion of using (and valuing) real options in the valuation of certain projects and we hence allow for some flexibility in how those options are best valued.

The business environment could be altered to test the generality of the model. The most restrictive assumption is our specification that capacity expansion is lumpy. This need not be the case and hence raises a few issues for discussion. In the previous section we demonstrated how adding the extra cost of investing in excess capacity to the Adjusted NPV of the foreign investment would affect the final decision. This implies that there is a trade-off between holding excess capacity (and gaining the option to switch) and expanding capacity in existing locations to meet demand. Firms need to question whether maintaining excess capacity is justified by the value of the portfolio of options. Most firms never attain full capacity utilization and if this is the case then maintaining that excess capacity in a foreign location may be preferred to maintaining excess capacity in another local plant, especially when inputs are immobile.³⁰

²⁹ Three processes that present themselves for selection include Brownian Motion with Drift, Mean Reverting Process and the Poisson Process. Each of these captures an interesting facet of wage rates. For example, the Poisson Process is best suited to mimic jumps/discontinuities in w^A , and further these may allow for a comparison between the mean values of the variables. However, with these processes analytical solutions are not guaranteed, and numerical solutions may be necessary. One way to extend this analysis would be to perform Monte Carlo simulations to determine whether the value is derived from the underlying stochastic process or else from having operational flexibility.

³⁰ See McRae (1990). Also, Kogut (1985), p.33 suggests that the loss in economies of scale should be less than the sum of the option to shift production and the cost of holding excess capacity.

The next assumption that is suspect is that demand was chosen to be three units and was not expected to change thereafter. We can modify this assumption to one where we allow demand to rise to four units at some time period T in the future. Now the options will have value from today until time period T, and then will have no value. Additional extensions to our approach could stem from assuming that demand too is stochastic. Two variations are possible : (a) a perfectly competitive environment where the price of output is stochastic and the firm has to decide how much to supply the market at that price (e.g. the chemical industry); (b) a monopolist facing a stochastic world demand curve. These two situations present a setting where choosing optimal capacity becomes a key decision, in addition to decisions on the location and timing of the investment.

We also assumed that production could be switched costlessly from one plant to another. With an extremely long horizon, and very low switching costs, we might find that further into the horizon, the expected switching cost could approach zero.³¹ Alternatively, we could assume that there is some fixed switching cost "s" that must be incurred to switch from country A to B or vice-versa. This would obviously reduce the value of the options, and will affect the optimal exercise rule that we used in the model.

A related assumption that begs scrutiny was that production could be switched from one country to another the moment the firm realizes that the wage rate in one country is higher than the wage rate in the other. On occasion, the company will be restrained from doing so by wage contracts and other factors. This delay greatly reduces the value of the options, because by the time the firm is ready to exercise the option to switch production, the option might not be in the money or as valuable.³²

Two other assumptions that are worthy of discussion are: factors of production (inputs) are immobile and that no tariffs or taxes exist. Essentially, we are using one market imperfection (immobility) and

³¹ I would like to thank Prof. Myers for pointing this out to me.

³² Once again Kogut (1985) argues that the value of flexibility depends on the ability of the firm to capitalize on differences in marginal costs when exchange rates fluctuate, and that some measure of industrial relations be included in the valuation.

assuming away all others. As long as we have a situation where the markets for the input in the two countries are separated by some exogenous condition (tariffs, different tax policies etc.) valuing these options may prove to be a fruitful exercise.

There are other issues that may need to be examined that were not explicitly addressed by the assumptions. We implicitly assumed that managers in each of the locations would be compensated by enlightened management in the parent company who would recognize their efforts to maximize the global optimum. Issues relating to management compensation may make the task of shifting capacity utilization a little more difficult than modeled in this paper. Extending the model to include some of the above may be warranted to get more realistic values for the options. The trade-off is that we may need more complex mathematical techniques and then closed-form solutions are not guaranteed. Finally, this model is designed to be illustrative rather than specific and hence we choose a relatively simple methodology to value flexibility.

Section VI

Implications

On a macro-policy level, countries that wish to encourage investment, either from domestic or foreign investors could extract the message that stability is desirable. The models suggest the increased volatility in factor markets and/or exchange rates increase the value of the option to postpone investment or else invest abroad.³³ Recent attempts by the European Community to integrate labor markets and align exchange rates will reduce the cost differentials between producing in any two member countries. Therefore, firms that have manufacturing facilities dispersed around Europe may find that the value of excess capacity may be greatly diminished. On the other hand, firms positioned to treat the European market as one market may reap the economies of scale of producing in one location. Here the key to optimal decision making will hinge on the definition of markets that will be truly independent so as to provide a cost differential.

An additional implication is for the correct valuation of MNEs by stock markets. While present wisdom indicates that the value of the firm is the present discounted value of all future cash flows, this analysis suggests that the value of intangibles, like flexibility, should be included.³⁴ Are MNEs consistently undervalued by capital markets because transactors do not incorporate the value of flexibility? That is an empirical question that is beyond the scope of this paper, but could provide additional avenues for research.

³³ Refer to Appendix and Pindyck (1988).

³⁴ Refer to Brealey and Myers - *Principles of Corporate Finance* - Chapter 21 for a description of some of the other intangibles that should be included in firm value.

Conclusions

MNEs or else firms considering multinationality should be careful to recognize that an investments in more than one country or in a different business environments are valuable when costs conditions are changing, because of the flexibility that these investments create for the entire multinational system. In this paper, we have demonstrated how excess capacity should be valued when MNEs can shift capacity utilization to the most favorable cost location. The value of the flexibility depends critically on the volatility (i.e.degree of correlation of the host and home country) in input markets and exchange rates and quite obviously, the greater the volatility (lower the degree of correlation) in these areas, the greater the value to being multinational. Finally, the paper shows how static NPV rules should be modified and that for US-domiciled MNEs, maintaining excess capacity in Europe is more valuable than maintaining excess capacity in Canada. Moreover, under certain conditions US-based MNEs might be willing to pay more to invest in excess capacity abroad than to expand capacity in the US.

Appendix I - Data for Tables 1 and 2

Hourly Wages in Manufacturing - Local Currency

Year	Canada	France	Germany	Ireland	Mexico	Spain	U.K.	U.S.
1990	14.3		20.07	5.33	3848		5.383	10.84
1989	13.54	36.7	19.1	5.1	3220	780	4.916	10.49
1988	12.84	35.35	18.33	4.9	2215	735	4.541	10.19
1987	12.24	34.35	17.53	4.7	1213	678	4.227	9.91
1986	11.95	33.28	16.8	4.5	327	620	3.961	9.73
1985	11.59	31.56	16.2	4.2	314	564	3.706	9.54
1984	11.16	28.86	15.49	3.9	235	514	3.43	9.19
1983	10.59	26.7	15.14	3.52	149	457	3.205	8.83
1982	10.25	23.97	14.64	3.17	101	399	2.977	8.49
1981	9.17	20.72	13.92	2.77	63	346	2.934	7.99
1980	8.19	18.46	13.18	2.32	39.02	285	2.664	7.27
1979	7.44	16.04	12.36	2.01	31.88	242	2.275	6.7
1978	6.84	14.2	11.73	1.7	28.16	198	1.949	6.17
1977	6.38	12.58	11.14	1.47	25.56	155	1.687	5.68
1976	5.76	11.11	10.35	1.262	22.16	135.97	1.559	5.22
1975	5.06	9.82	9.69	1.099	15.44	104.73	1.399	4.83
1974	4.37	8.39	8.94	0.83	13.8	78.82	1.116	4.42
1973	3.85	7.05	8.03	0.688	10.64	62.48	0.929	4.09
1972	3.54	5.82	7.24	0.559	8.68	52.2	0.821	3.82
1971	3.28	5.18	6.66	0.491	7.94	44.81	0.72	3.57
1970	3.01	4.66	5.96	0.424	7.32	39.47	0.644	3.36
1969	2.79	4.21	5.28	0.36	6.82	34.69	0.559	3.19
1968	2.58	3.79	4.79		6.33	31.16		3.01
Average	7.86	17.85	12.29	2.51	517.77	298.06	2.53	6.81
Std. Dev.	3.90	11.61	4.66	1.75	1080.6	254.42	1.50	2.71

This data is taken from the Yearbook of Labor Statistics. Hourly wages in manufacturing = earnings per hour, which is pre-tax, includes overtime, but does not include employer contributions for social security etc.

	End of Year Exchange Rate (LC/\$)						
Year	Canada	France	Germany	Ireland	Mexico	Spain	U.K.
1990							
1989	1.1578	5.794	1.6952	0.64475	2637	109.7	0.62391
1988	1.1918	6.1332	1.7975	0.6714	2263	113.6	0.5571
1987	1.3048	5.513	1.5983	0.603	2198.5	108.85	0.5388
1986	1.3805	6.425	1.94	0.7148	923	131.88	0.6771
1985	1.3988	7.56	2.465	0.806	369.4	154.3	0.6951
1984	1.323	9.6995	3.17	1.016	191.88	174.85	0.873
1983	1.248	8.517	2.786	0.8978	144.37	156.63	0.706
1982	1.2295	6.6565	2.3485	0.7075	95	124.8	0.615
1981	1.1817	5.7275	2.2625	0.6353	25.98	97.55	0.526
1980	1.17786	4.54	1.959	0.527	23.07	79.215	0.4188
1979	1.16523	4.01925	1.7155	0.4287	22.82	66.04	0.4485
1978	1.18843	4.2425	1.85125	0.4973	22.72	70.425	0.4969
1977	1.09218	4.6205	2.0655	0.5067	22.66	80.09	0.5067
1976	1.002	4.9307	2.3492	0.5839	19.975	68.24	0.5839
1975	1.0121	4.4425	2.598	0.4916	12.4906	59.535	0.4916
1974							
1973							
1972							
1971							
1970							
Average	1.20	5.92	2.17	0.65	598.12	106.38	0.58
Std. Dev.	0.12	1.65	0.45	0.16	948.70	36.49	0.12

Appendix II - Determining the value of $R(\Delta)$ and $N(\Delta)$

$$d\Delta = \sigma_{\omega} dz \quad (1)$$

where $dz = \varepsilon(t)(dt)^{1/2}$ is the increment on standard Brownian motion. $\varepsilon(t)$ has zero mean and unit standard deviation. $E[dz] = 0$ and $E[(dz)^2] = dt$. σ_{ω} is the instantaneous standard deviation.

If the firm expands capacity in country A then its costs in every period are $(x+d)w^A$ as long as the unit labor cost is below p . If w^A exceeds p , the firm may want to shut down, unless it is trying to protect market share. However, if the firm invests in country B to complement its original investment in A, then costs are equal to $\min[xw^A + dw^*, dw^A + xw^*]$. Therefore, a simple NPV analysis to evaluate the investment in B that assumed that the plant in B would produce only one unit of output would underestimate the true value of the foreign investment. A static NPV analysis might assume that the extra unit of capacity will be left unused at all times, given insufficient demand, whereas the approach we present below takes into account the benefit of maintaining that extra unit of capacity when unit costs in one environment are more volatile than they are in another.

If we assume that shutdown is costless and that the firm will not produce output in A when the wage rate in A exceeds the price of output, we can find the value of flexibility.

$$\text{Define } b = p - w^* \quad (2)$$

$$\text{Define } w^A = w^* + \Delta \quad (3)$$

$$\text{This implies that } p - w^A = b - \Delta \quad (4)$$

$$\text{Now the cash flows generated by a national firm} = (x+d)(p - w^A)^+ \quad (5)$$

$$\text{where we define } (p - w^A)^+ = \max[p - w^A, 0] \quad (6)$$

For simplicity assume that $x = 2$ and $d = 1$.

Therefore, if the firm expands capacity at home, the cash flows generated by a national firm in every period (ignoring time subscripts)

$$= 3(p - w^A)^+ = 3(b - \Delta)^+ = (x+d)(b - \Delta)^+ \quad (7a)$$

since expanding capacity at home will generate additional cash flows
 $= (b - \Delta)^+$ in every period ($= d(b - \Delta)^+$). (7b)

On the other hand, the cash flows generated by a MNE in every period
 (ignoring time subscripts)

$$= (p - w^A)^+ + b + p - \min(w^A, w^*) \quad (8a)$$

$$= (b - \Delta)^+ + b + p - (w^* + \min(\Delta, 0)) \quad (8b)$$

$$= 2b + (b - \Delta)^+ - \min(\Delta, 0) \quad (8c)$$

$$= 2b + (b - \Delta)^+ + \max(-\Delta, 0) \quad (8d)$$

$$= 2b + (b - \Delta)^+ + (-\Delta)^+ \quad (9)$$

$$\left[\text{Alternatively, } = xb + d(b - \Delta)^+ + (x - d)(-\Delta)^+ \right]$$

Notice though that the incremental cash flows of the foreign project = cash flows provided by a MNE less the cash flows that existing investments in the home country will provide. From (7a), (7b) and (9), we find that incremental cash flows

$$= 2b + (b - \Delta)^+ + (-\Delta)^+ - 2(b - \Delta)^+ \quad (10a)$$

$$= 2b - (b - \Delta)^+ + (-\Delta)^+ \quad (10b)$$

$$\left[\text{Alternatively, } = xb - (x - d)(b - \Delta)^+ + (x - d)(-\Delta)^+ \right]$$

Equation (10b) will be crucial for our calculation of operational flexibility.

The expected value of the MNE is the expected discounted value of future cash flows. Therefore define $M(\Delta)$ = Value of the MNE. From (9)

$$M(\Delta) = E_t \left[\int_{t=0}^{\infty} e^{-rt} [2b + (b - \Delta_t)^+ + (-\Delta_t)^+] dt \mid \Delta_0 = \Delta \right] \quad (11)$$

$$\text{Define } N(b, \Delta) = E_t \left[\int_{t=0}^{\infty} e^{-rt} [(b - \Delta_t)^+] dt \mid \Delta_0 = \Delta \right] \quad (12)$$

$$\text{or } N(b, \Delta) = \max_{j=0/1} E_t \left[\int_{t=0}^{\infty} e^{-rt} [j(b - \Delta_t)] dt \mid \Delta_0 = \Delta \right]$$

Given that Δ follows the stochastic process specified in (1), the Bellman equation for the value of the portfolio of options $N(b, \Delta)$ is

$$rN = \max_{j=0/1} \left\{ j(b - \Delta) + \frac{1}{dt} E_t dN \right\} \quad (13)$$

$$\text{By Ito's Lemma } dN = N' d\Delta + \frac{1}{2} N'' (d\Delta)^2 \quad (14)$$

where the prime denotes the derivative with respect to $(b - \Delta)$. Substituting for $d\Delta$,

$$dN = \sigma_{\omega} N' dz + \frac{1}{2} \sigma_{\omega}^2 N'' dt \quad (15)$$

Plugging (15) into (13),

$$rN = \max_{j=0/1} \left\{ j(b - \Delta) + \frac{1}{2} \sigma_{\omega}^2 N'' \right\} \quad (16)$$

Maximizing with respect to j : set $j = 1$ if $(b - \Delta) > 0$ (produce the unit of output) and set $j = 0$ (do not produce the unit of output) otherwise.

We need to solve

$$\frac{1}{2} \sigma_{\omega}^2 N'' - rN + j(b - \Delta) = 0 \text{ subject to the following conditions:} \quad (17)$$

$$N(\infty) = 0 \quad (18a)$$

$$\lim_{\Delta \rightarrow -\infty} N = \frac{b - \Delta}{r} \quad (18b)$$

$$N(\Delta = b^+) = N(\Delta = b^-) \quad (19a)$$

$$N'(\Delta = b^+) = N'(\Delta = b^-) \quad (19b)$$

where the prime denotes the derivative w.r.t. $b - \Delta$.

Condition (18b) states that when $\Delta = -\infty$, wages at home are substantially below wages abroad, and the firm will earn $p - w^A$ in every period. (18a) is included because as w^A becomes very large, the probability that the firm produces output at home goes to zero. (19a) and (19b) are the smoothness and continuity conditions.

$$\text{Therefore } N(b, \Delta) = a_1 e^{(-b+\Delta)g} + \frac{b-\Delta}{r} \quad \text{when } \Delta < b \quad (20a)$$

$$= a_2 e^{(b-\Delta)g} \quad \text{when } \Delta > b \quad (20b)$$

where $g^2 = \frac{2r}{\sigma_\omega^2}$, and e is the base for the natural logarithm.

$$\text{From the continuity conditions we find that } a_1 = a_2 = \frac{1}{2rg}. \quad (21)$$

$[N'(\Delta = 0^+) = N'(\Delta = 0^-) \Rightarrow -gae^{-\Delta g} + \frac{1}{r} = gae^{\Delta g} \Rightarrow 2ag = \frac{1}{r}$ which is solved for
a]

$$N(b, \Delta) = \frac{1}{2rg} e^{(-b+\Delta)g} + \frac{b-\Delta}{r} \quad \text{when } \Delta < b \quad (22a)$$

$$= \frac{1}{2rg} e^{(b-\Delta)g} \quad \text{when } \Delta > b \quad (22b)$$

Define $N(\Delta)$ = expected value of a unit of capacity in the home country. From (7b) and (12) we know that $N(\Delta) = N(b, \Delta)$, which is given by (22a) and (22b).

A brief explanation of (22a) and (22b) is in order. Let us examine (22a) first. When $\Delta < b$, this implies that $p > w^A$ and the firm is producing output at home. If the wage in A were never to change the present value of all earnings = $\frac{b-\Delta}{r}$. However, should the wage in A rise above p , the firm will shutdown and the value of this option = $\frac{1}{2rg} e^{(-b+\Delta)g}$. (22b) states that if the wage in A is higher than p , the firm is not producing output, but has the option to produce output when the wage rate in A falls. The value of the option to restart production = $\frac{1}{2rg} e^{(b-\Delta)g}$.

We can conclude from (7a) that the expected value of the national firm is = $3N(\Delta) = (x+d)N(\Delta)$.

$$\text{What is } E_t \left[\int_0^{\infty} e^{-rt} [(-\Delta_t)^+] dt \mid \Delta_0 = \Delta \right] ? \quad (23)$$

This is nothing but $N(b, \Delta)$, where $b = 0$.

Under the usual boundary, smoothness and continuity conditions, it can be shown from the work above that

$$N(0, \Delta) = \frac{1}{2rg} e^{(\Delta)g} + \frac{-\Delta}{r} \quad \text{when } \Delta < 0 \quad (24a)$$

$$= \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } \Delta > 0 \quad (24b)$$

From (11) we had defined $M(\Delta) = \text{Expected value of the MNE}$, and

$$M(\Delta) = E_t \left[\int_0^{\infty} e^{-rt} [2b + (b - \Delta_t)^+ + (-\Delta_t)^+] dt \mid \Delta_0 = \Delta \right]$$

$$= \frac{2b}{r} + N(b, \Delta) + N(0, \Delta)$$

Using the results derived in (22a), (22b), (24a) and (24b) we can show that $M(\Delta)$

$$= \frac{2b}{r} + \frac{1}{2rg} e^{(-b+\Delta)g} + \frac{b-\Delta}{r} + \frac{1}{2rg} e^{(\Delta)g} + \frac{-\Delta}{r} \quad \text{when } \Delta < 0 \quad (25a)$$

$$= \frac{2b}{r} + \frac{1}{2rg} e^{(-b+\Delta)g} + \frac{b-\Delta}{r} + \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } 0 \leq \Delta \leq b \quad (25b)$$

$$= \frac{2b}{r} + \frac{1}{2rg} e^{(b-\Delta)g} + \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } \Delta \geq b \quad (25c)$$

These can be rewritten as

$$= \frac{b}{r} + \frac{2(b-\Delta)}{r} + \frac{1}{2rg} e^{(-b+\Delta)g} + \frac{1}{2rg} e^{(\Delta)g} \quad \text{when } \Delta < 0 \quad (25a)$$

$$= \frac{2b}{r} + \frac{1}{2rg} e^{(-b+\Delta)g} + \frac{b-\Delta}{r} + \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } 0 \leq \Delta \leq b \quad (25b)$$

$$= \frac{2b}{r} + \frac{1}{2rg} e^{(b-\Delta)g} + \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } \Delta \geq b \quad (25c)$$

We briefly describe what the above equations imply. Consider (25a). When $\Delta < 0$, the wage rate in A is less than the wage rate in B, and the firm is

producing two units of output at home ($= \frac{2(b-\Delta)}{r}$) and one in the foreign location ($= \frac{b}{r}$), with the option to produce two units abroad if the wage rate at home rises above the wage rate abroad, and the option to not produce at all in A if the wage in A rises above p . For (25b) we consider the region where the wage at home is higher than the wage abroad, but below the price of output. Now, the firm is producing two units in the foreign location, and one at home, but it has the option to switch or shutdown production at home. (25c) examines the case where $w^A > p$, and now the MNE is producing two units of output ($= \frac{b}{r}$) abroad, but has the option to restart domestic production.

To value flexibility we determine the incremental cash flow of the foreign project, and deduct the cash flows from producing one unit of output abroad. This calculation provides us with the cash flows that the foreign project would generate over and above satisfying the increase in demand. From (10b) we know that the incremental cash flow provided by the foreign project $= 2b - (b - \Delta)^+ + (-\Delta)^+$. Therefore the CFs associated with flexibility $= 2b - (b - \Delta)^+ + (-\Delta)^+ - b$ (26)

because b is the guaranteed cash flow produced by the foreign investment from satisfying the unit increase in demand.

$$\begin{aligned} & \left[\text{Alternatively, } = xb - (x-d)(b-\Delta)^+ + (x-d)(-\Delta)^+ - db \right. \\ & \left. = (x-d)b - (x-d)(b-\Delta)^+ + (x-d)(-\Delta)^+ \right] \end{aligned}$$

Define $R(\Delta)$ = value of flexibility = expected present value of all cash flows that the foreign project generates through the optimal usage of excess capacity. Then from (26) we know that

$$R(\Delta) = E_t \left[\int_{t=0}^{\infty} e^{-rt} [b - (b - \Delta_t)^+ + (-\Delta_t)^+] dt \mid \Delta_0 = \Delta \right] \quad (27)$$

Once again, with appropriate boundary, smoothness and continuity conditions it can be shown that $R(\Delta) = \frac{b}{r} - N(b, \Delta) + N(0, \Delta)$

$$= \frac{b}{r} - \frac{1}{2rg} e^{(-b+\Delta)g} - \frac{b-\Delta}{r} + \frac{1}{2rg} e^{(\Delta)g} + \frac{-\Delta}{r} \quad \text{when } \Delta < 0 \quad (28a)$$

$$= \frac{b}{r} - \frac{1}{2rg} e^{(-b+\Delta)g} - \frac{b-\Delta}{r} + \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } 0 \leq \Delta \leq b \quad (28b)$$

$$= \frac{b}{r} - \frac{1}{2rg} e^{(b-\Delta)g} + \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } \Delta \geq b \quad (28c)$$

These equations can be reduced to the following

$$= \frac{1}{2rg} e^{(\Delta)g} - \frac{1}{2rg} e^{(-b+\Delta)g} \quad \text{when } \Delta < 0 \quad (28a)$$

$$= \frac{\Delta}{r} - \frac{1}{2rg} e^{(-b+\Delta)g} + \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } 0 \leq \Delta \leq b \quad (28b)$$

$$= \frac{b}{r} - \frac{1}{2rg} e^{(b-\Delta)g} + \frac{1}{2rg} e^{(-\Delta)g} \quad \text{when } \Delta \geq b \quad (28c)$$

The interpretations for (28a), (28b) and (28c) are very similar to those detailed above with respect to equations (25a), (25b) and (25c). From (28a) we conclude that when $\Delta < 0$, the wage rate at home is less than the wage rate in B, and even though the firm is not using the excess capacity abroad, it has the option to do so in the future. However, if w^A should rise above the price of output, the maximum saving afforded by the foreign investment is = b in every period. When $0 \leq \Delta \leq b$, then the wage in A is above the foreign wage and below p . We find from (28b) that if the wage in A were never to change the present value of all cost savings provided by excess capacity abroad = $\frac{\Delta}{r}$.

However, if the wage rate in A should fall below the wage rate abroad, the firm will want to switch production back to the home country, and this is a valuable option. In addition, if the wage rate in A rises above p , the maximum cost saving from producing the third unit of output abroad in every period = b . Equation (28c) considers the case where w^A is greater than p and the analysis is similar to that described above for equation (28b).

Appendix III

Suppose we assumed that the wages in country A and country B were stochastic. How would the valuation of flexibility and that of the MNE be affected ?

$$\text{Define } \Delta = (w^A - w^B) \quad (1)$$

$$\text{Assume that } dw^A = \sigma_A dz \text{ and that } dw^B = \sigma_B dz \quad (2)$$

$$\text{Then } d\Delta = d(w^A - w^B) = \sigma dz \quad (3)$$

because the difference between two Brownian Motions is a Brownian Motion, if the joint distribution is Brownian.

$$\text{If we define } b_t = p - w^B(t)$$

The cash flows generated by a MNE in every period (ignoring time subscripts)

$$= (p - w^A)^+ + (p - w^B)^+ + p - \min(w^A, w^B) \quad (4a)$$

$$= (p - w^A)^+ + (p - w^B)^+ + (p - w^B)^+ - \min(-\Delta_t, 0) \quad (4b)$$

$$= 2(b_t)^+ + (p - w^A)^+ - \min(-\Delta_t, 0) \quad (4c)$$

which is clearly different from the assumption made in Appendix III, because b_t is not fixed in every period. This is a difficult model to solve, and it is clear that if we allow wages in country B to be stochastic then this in turn will affect the cash flows associated with flexibility. However, we can treat the value of flexibility derived in Appendix III as a first approximation for the value of flexibility when wages in both countries are stochastic.

Appendix IV

An interesting extension to the work presented above is to attempt to draw implications for firms about the optimal timing and optimal location of investment. The questions a firm must consider is not only whether to invest today versus invest tomorrow, but also whether to invest at home or abroad.

Pindyck (1991) demonstrates how a firm should value the option to invest when investment is irreversible and in other work (Pindyck (1988)) presents a methodology for valuing incremental capacity. The critical idea is that when demand is stochastic, the firm has the option in every period to decide whether or not to use a unit of capacity. The firm acquires this portfolio of options when it invests in a unit of capacity. However, the key decision for the firm is the investment decision i.e. whether it should pay a sunk cost to acquire that unit of capacity today or else wait till some future period. From his work he is able to show that in the presence of stochastic demand firms may postpone investment rather than invest today.

In the work to follow we will try to show how the option to invest might be valued for a domestic firm when investment is irreversible, marginal costs are stochastic and the price of output is fixed. From Appendix II we know that the value of expanding capacity at home today = $N(\Delta)$

$$N(\Delta) = \frac{1}{2rg} e^{-\Delta g} + \frac{\Delta}{r} \quad \text{when } \Delta > 0 \quad (1a)$$

$$= \frac{1}{2rg} e^{\Delta g} \quad \text{when } \Delta < 0 \quad (1b)$$

What is option to invest ?

The firm can either invest today by paying \$I (a sunk cost) and acquire a project of value $N(\Delta)$, or else wait until some future period.

Let $F(\Delta)$ = option to invest in country A.

$$F(\Delta) = \max E_t [(N_T - I) e^{-rT}] \quad (2)$$

where T = time period when the firm decides to make the investment.

The corresponding Bellman equation is

$$rF = \frac{1}{dt} E_t dF \quad (3)$$

$$\text{By Ito's Lemma } dF = F'd\Delta + \frac{1}{2} F'' (d\Delta)^2 \quad (4)$$

where the prime denotes the derivative with respect to Δ . Substituting for $d\Delta$,

$$dF = \sigma F'dz + \frac{1}{2} \sigma_p^2 F'' dt \quad (5)$$

Plugging (5) into (3), we need to solve for F .

$$rF = \frac{1}{2} \sigma_p^2 F'' \quad \text{subject to the following conditions} \quad (6)$$

$$F(\Delta = -\infty) = 0 \quad (7a)$$

$$F(\hat{\Delta}) = N(\hat{\Delta}) - I \quad (7b)$$

$$F_{\Delta}(\hat{\Delta}) = N_{\Delta}(\hat{\Delta}) \quad (7c)$$

where $\hat{\Delta}$ = optimal value for Δ at which you will exercise.

A solution to the above is

$$F(\Delta) = ne^{\Delta g} \quad \text{when } \Delta < \hat{\Delta} \quad (8a)$$

$$= N(\hat{\Delta}) - I \quad \text{when } \Delta > \hat{\Delta} \quad (8b)$$

$$\text{where } n = \frac{1}{2} \left[\frac{\hat{\Delta}}{r} + \frac{1}{gr} - I \right] e^{-\hat{\Delta}g} \quad \text{and } \hat{\Delta} \text{ is the solution to} \quad (9)$$

$$\frac{\hat{\Delta}}{r} + \frac{1}{gr} e^{-\hat{\Delta}g} = I + \frac{1}{gr} \quad (10a)$$

$$\text{Rewriting (10a), } \hat{\Delta} \text{ is the solution to } g\hat{\Delta} + e^{-\hat{\Delta}g} = Irg + 1. \quad (10b)$$

If we attempt to extend this analysis to an optimal investment timing problem we find that while greater volatility makes a unit of capacity more valuable because of the option to shut down, increased volatility also has the characteristic of making the option to wait more valuable. Since the volatility of domestic costs in the U.S (1.91) is greater than the measure of volatility of cost savings of countries like Germany, Canada and U.S. hourly wages are

below those of Germany and Canada, U.S. firms will exercise the option to wait rather than acquire the factory today.³⁵

Therefore, we suggest that management of firms that operate in the global economy, that are considering increases in capacity expansion, be cognizant of not only domestic business conditions, but also opportunities that foreign locations provide to increase firm value. As we have shown in this Appendix, imbedded options in investments at home and abroad clearly affect investment timing and location decisions and hence must be valued carefully.

³⁵ In 1985, when the dollar appreciated significantly, US firms might have found it preferable to invest in countries like Germany, UK and Ireland, rather than wait to invest at home. On the other hand, in low wage countries like Mexico or Thailand, the direct cost advantage may clearly offset any benefit to waiting to invest at home. In these low cost countries, U.S. based MNEs will find it advantageous to invest abroad today, rather than wait to invest at home.

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