Foreign Direct Investment as a Real Option: The Role of Managerial Flexibility and Uncertainty in Foreign Investment Decision

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Abstract: This study examines the characteristics of switching option equilibrium of a multinational firm. Based on an extensive literature survey, the point of this study we emphasise is that foreign direct investment (FDI, hereafter) is exercised by a real option motivation. In this paper, we assume that an international firm serves foreign markets by either export or FDI. The choice between the two operations is determined by stochastic dynamic optimisation. The real option model of McDonald and Siegel (1986) is applied to the investment decision of the firm. The results show that (1) under market uncertainty the firm will be able to maximise its value by switching between export and FDI, (2) the threshold exchange rate to switch between the two operations is different from the one derived from Net Present Value principle, (3) a delayed decision of switching mode depends on uncertainty of exchange rate, and (4) the more volatile the exchange rate is, the more the firm is inclined to maintain the current operation mode and the more the value of the firm increases. These results suggest that an international company may implement FDI even without any competitive advantage the company enjoys. Our findings are qualitatively different in several aspects from those shown by Dixit (1989). A numerical example is also examined to clarify these results.

Keywords: *Foreign Direct Investment (FDI), Managerial Flexibility, Real Options, Exchange Rate Volatility*
JEL Classification: *F23 G12*

1. INTRODUCTION

Over the past few decades, there has been a long debate on what factors determine the international operation modes of a multinational enterprise. An international company may conduct its business through export and import, licensing, sales of technology (patents), management consulting contracts, selling turnkey plants and undertaking portfolio investment. Why, then, is sometimes FDI chosen among other alternatives? Therefore, any theory of FDI must address the following questions. First, why do firms choose to enter a foreign country through FDI, rather than exporting or licensing? Secondly, how can foreign firms compete successfully against local competitors in the host country, where they are at a disadvantage in operating in an unfamiliar business environment?

Mainstream literatures on the theory of multinational enterprises (MNEs, hereafter) are

likely to emphasise national and firm-specific factors as well as market imperfections, e.g. proprietary knowledge, internalisation, product differentiation and domestic industrial structure, as determinants of entry mode. However, the neglected factor on the advantage of a multinational firm is its flexibility to transfer resources across borders through the global network. Under this circumstance, FDI is one of the vehicles for a multinational company to enjoy managerial flexibilities. Flexibility has its own economic value. Although an international company always faces uncertainty in foreign markets, such as local demand biases, local potential competition, changes in local government policy, exchange rate volatility and other forms of unforeseeable events, the option theory tells us that uncertainty will, if successfully managed, contribute to increase, rather than decrease, the value of the firm. A stochastic process of the price change, for example, of an investment project leads to uncertainty over the future flow of operating profits. Then, firm's managerial flexibility will be able to minimise the downside risk, whilst at the same time it is to maximise the potential upward gains. Based on this argument, investment in overseas operations generates an option value through the potential to shift international operations between export and overseas productions. Thus, option thinking may lead us to believe that FDI will be exercised even under circumstances in which any factors related to O-L-I advantages (See section 2-(c)) and market imperfectness are not available to an international firm.

This paper builds switching option model between FDI and export operations of an international firm. The pioneering works on real options by McDonald and Siegel (1985, 1986), Brennan and Schwartz (1985), Majd and Pindyck (1987), Pindyck (1988), and Dixit (1989) show that waiting can be optimal under uncertainty. The model employed in this study is based on McDonald and Siegel's (1986) on the investment timing decision of a monopolist; however, the firm in this study is assumed to operate under perfect competitive market and, therefore, the price and output of firm's product is exogenously given. Uncertain appears in a form of exchange rate fluctuation. Net profit from export is exposed to exchange rate fluctuation; on the other hand, benefit from overseas production is more stable and free from the exchange rate uncertainty. Thus, FDI can be analogous to put options in which overseas production will contribute to minimising a downside risk when exchange rate is getting unfavourable to gaining profit from export.

We should also note that, when faced with an immediate or never investment opportunity, the net present value (NPV) rule prescribes acceptance. When there is an option to defer investment, one is effectively faced with a continuum of mutually exclusive projects indexed by their starting dates. In this case, the NPV rule recommends acceptance of the NPV-maximising alternative. However, the optimal alternative need not be immediate investment. The nature of deference to invest appears, in this study, stickiness to a current operation mode of entry.

The paper proceeds as follows. Section 2 reviews the literatures on the theory of FDI and multinational enterprises. In section 3, we construct a real option model of an international firm. The firm is able to switch the mode of operations between FDI and export. The threshold exchange rate at which the firm optimally starts overseas production plays a central role in the model. Section 4 shows numerical examples and examines implications of the results. In section 5, we conclude our study.

2. A CRITICAL REVIEW OF THE LITERATURE

The central question in the theory of FDI and the Multinational enterprise is to explain why an international firm can successfully invest in overseas operations. The traditional literatures emphasise several types of advantages and market structure around the firm as the determinants. However, thanks to the recent theoretical development of financial engineering, the economic merits of the multinational firms as a global network can be fairly evaluated by the option valuating methods. In this section, we briefly review articles on FDI and multinational enterprise and will understand how significantly the nature of managerial flexibility has been neglected in the mainstream of the FDI theories.

(a) the Heckscher-Ohlin Tradition

Partly because of the Ricardian assumption that production factors, such as capital and labour, are immobile between nations, FDI has not attracted much attention in neoclassical trade theory. The assumptions of the Heckscher-Ohlin theory, including constant return to scale, perfect competition in factor and product markets, immobility of production factors, identical production functions, the absence of risk and uncertainty, no transportation costs, and free technology transferability, are incompatible with the reality of FDI flows across border. Even if initial factor endowments differ between two countries, free trade will equalise the factor price ratio between the two economies, eliminating arbitrage profits from factor movements.

FDI is possible only if several assumptions of the Heckscher-Ohlin theory are violated, for example, when there is a large difference in the factor endowment between two countries and, at the same time, imperfect competition exits in factor and product markets. In such a case, one country may specialise in producing only one commodity and, as a result, the factor price equalisation cannot be realised. Even so, FDI simply appears as an arbitrage movement of capital, which shifts equity from countries where returns are low to those where they are higher (MacDougall 1960, Kemp 1966). Clearly, even in this case, there is no distinction between direct investment and portfolio investment.

Existing trade theory conflicts increasingly with the evident facts of a world economy in which the activities of MNEs are becoming important. Recent developments in the theory of international trade can partly be explained as an effort to fill the gap between theory and reality. The 'new trade theory' emphasises several features that are essential to explanations of FDI, including economies of scale, monopolistic competition, strategic interactions, and technological spillovers (Helpman 1984, Markusen 1984, Ethier and Markusen 1996, and Markusen and Venables 1998, 2000). Their models are structured with a general equilibrium framework in which FDI is endogenously determined corresponding to relative factor endowment, country size, and world income level. The conclusion of these studies emphasises the role of MNEs in global allocative efficiency.

Neoclassical economics puts too much stress on theoretical consistency between FDI and the Heckscher-Ohlin tradition, however. This is potentially problematic. The new trade theory also pays little attention to the organisational nature of MNEs in which production and transactions are governed and controlled under a hierarchical ownership structure. Although FDI is un-

dertaken by individual firms, it appears that, in a general equilibrium framework, FDI is carried out by industries or countries. This is obviously a misleading setting. Ownership of tangible and intangible assets by an individual firm is critically important to explain FDI activity, yet neoclassical economics fails to involve them. Neoclassical economics cannot identify the ability of foreign investing firms to shift and the control of technology and other assets across borders, which is an essential part of FDI analysis. Thus, an analysis incorporating firm-firm or firm-market interactions is a more appropriate approach to FDI[1]. In this respect, Hymer's (1960) approach is superior to neoclassical economics.

(b) Hymer's Contribution

The contribution of Hymer (1960) to the study of FDI was undoubtedly epoch-making. He was dissatisfied with the then-dominant approach to FDI that made no distinction between FDI and cross-border portfolio investment. The core of Hymer's theory is threefold. Firstly, he regards the FDI flows as the transfer of a package of resources including technology, management know-how, entrepreneurship, and financial capital. Secondly, he argues that FDI should be carried out when investing firms have firm-specific advantages to which existing or potential local competitors have no access. Thirdly, he introduces an industrial organisation approach to FDI analysis. Although all three contributions are important, ownership advantage stands central to his argument. In other words, firm-specific advantages are a necessary condition for FDI. The logic runs as follows: MNEs always face a number of disadvantages when competing with domestic firms in a foreign market, such as distance from the home country, different languages, cultures, legal systems and the knowledge of customer preferences. In order to overcome these disadvantages, the MNEs must have some kind of firm-specific advantages, such as brand name, patent-protected superior technology, marketing and managerial skills, cheaper sources of financing, global networks or economies of scale, which are transferable to subsidiaries and enable the MNEs to gain more profit than it would at home. Thus, FDI automatically requires the transfer of resources.

Meanwhile, the ownership advantage, which Hymer assumed to be exclusive to the firm, may hinder perfect competition and, as a result, cause some kind of structural market failure. Consequently, as he argues, FDI is typically witnessed in oligopolistic markets. In other words, as perfect competition does not allow the creation of excess profit, the very existence of multinational firms rests on market imperfections. Let us suppose a case where an overseas market now operates under perfect competition. If demand for the product increases there, existing firms will enjoy excess profit. Even in this case, according to Hymer's theory, MNEs will not enter the market. Since the market operates under pure competition, the excess profit will disappear sooner or later following a new entry or product expansion by local firms. On the other hand, if a for-

[1] A noticeable contribution along these lines is Markusen (1984) in which FDI is modelled as a form of multi-plant operations. However, there is a critical shortcoming in this study. The model assumes that the tariff is imposed not by the host country but by the source country, which clearly contradicts with widely observed trade policies. Moreover, the study fails to derive any clear implications for FDI. Ethier and Horn (1990) introduce the hierarchical structure of an investing firm; however, the assumption of hierarchy only implies incurring additional costs and therefore, is less critical to the central issue.

eign firm has a firm-specific advantage, it can exclude local firms and make full use of its oligopolistic market power. In this sense, FDI is logically incompatible with a perfect competitive market, and indeed, global FDI largely occurs in the highly concentrated markets (United Nations 1997).

Finally, an analysis of oligopolistic markets requires an industrial organisation approach. An oligopolistic market allows firms to play strategically. Equilibrium prices and the optimal output of an individual firm depend on the behaviour of competitors in an oligopolised market. Knickerbocker (1973) argues that a risk-minimising oligopolistic firm would normally penetrate foreign markets to safeguard its own commercial interest. We may say that, while Hymer views FDI as an aggressive strategy by firms to advance their ownership advantages, Vernon (1973) and Knickerbocker regard it as a rather defensive strategy by oligopolistic firms to protect the market position they possess.

The argument of Hymer is not a decisive single explanation of FDI's motivation, however. In fact, there still remains the question of why, if an overseas market is oligopolised, does a foreign firm choose FDI, instead of exports to enter the market? Therefore, Hymer's theory must also explain why FDI is more profitable than exporting[2]. His answer to this question was not clear, however. As Buckley and Casson (1976) note, Hymer pointed out two advantages of FDI over other cross-border strategies. First, since the markets for information, knowledge and patents are imperfect, internalisation through FDI is superior to arm's-length transactions. Secondly, firm's operations abroad often enjoy low production costs and the possibility of gaining information about local preferences. Thus, as Hymer himself admits, FDI is explained not only by ownership advantage but also by other complementary explanations such as internalisation and location factors. As will be examined in the next part, this idea has been developed under the name of eclectic theory.

(c) Eclectic Paradigm (O-L-I theory)

Following Hymer's contribution, management scholars investigated his suppositions regarding the costs of foreign operations in foreign countries and unfamiliar labour relation under different cultures. Because of the inherent disadvantages and the high cost of foreign operations, it is necessary to identify the advantages and conditions under which FDI is viable. Dunning (1973, 1980) proposes the O-L-I (Ownership- Location- Internalisation) framework, or eclectic theory, which seeks to build a general model to determine the pattern and extent of FDI. The approach suggests three conditions all needed to account for a firm's motivation to undertake FDI. The three factors are explained as follows.

First, a firm should possess some *ownership* advantages, including intangible assets such as a patent or the ability to manage or organise some specific endeavour. Such advantages may be temporary or permanent but are exclusive to the firms. They promise superior returns over those of competitors in foreign markets.

Secondly, *location* advantage explains why firms do not concentrate their investments in one

[2] In fact, exporting and FDI are not mutually exclusive. Horst (1971, 1973) showed that overseas production and export can be compatible, depending on the marginal cost, transportation cost, fixed cost and elasticity of demand.

country and export to others. Location advantage refer to factors specific to a particular place and that have to be used in that place, such as protective trade barriers, labour advantages (costs and skills), natural resources, proximity to final markets, efficiency of transportation, geography, communication facilities, favourable government policies, and cultural factors.

Thirdly, the *internalisation* of global transactions can be preferable to arm's length use of markets. Internalisation advantages include the benefits to a firm of using its internal assets instead of buying or selling through the market. Examples include the merits of vertical upstream and/or downstream integration of operations, the ability to cross-subsidise products, economise on transaction and negotiation costs, and minimise uncertainty about buying and selling, the managerial ability to control supplies of inputs and their conditions of sale, and so on. Thus, there are advantage to MNEs in conducting its own foreign manufacturing rather than licensing, or contracting out to a foreign firm.

These three elements of eclectic theory, however, are not equally important. For example, ownership advantage does not explain the reason why a large market like the U.S. attracts many MNEs including from the developing world. If less competitive firms from developing countries can access the market and earn even a tiny profit, this is a large benefit for them. Thus, ownership advantage seems less important or even redundant. Casson (1987 p.32-36) posits that the advantage of internalisation alone is sufficient to explain FDI activity. He argues that intermediate markets are internalised as long as benefits exceed costs. FDI appears naturally when internalisation is carried out across borders (Buckley and Casson 1976, Rugman 1980). Thus, eclectic theory is often criticised as being less of a theory than an enumeration of possible explanations of FDI.

Moreover, eclectic theory, including internalisation theory, cannot explain several important aspects of FDI. First, these theories are static and therefore fail to explain the dynamic nature of FDI. They postulate that the magnitude of FDI flows is optimal at the point where marginal costs equal marginal revenue of FDI. As long as the economic environment remains unchanged, there seems to be no incentive for firms to expand their operations beyond this point. Obviously, this is not a sufficient description of international investment. As Pitelis notes, "existing work fails adequately to address the issues of motivation, internal inducements, and direction of expansion" (Pitelis 2000, p.197). In fact, foreign affiliates have their own vocation to expand (Penrose 1956).

The second shortcoming of eclectic and internalisation theories is that they, as well as Hymer, somehow disregard the managerial flexibility of foreign operations. Foreign subsidiaries are part of an internationally coordinated strategy of the corporation. The coordination of a network of subsidiaries dispersed throughout the world provides an 'operating flexibility' that should add value to the firm. Operational flexibility is an advantage for a multinational corporation, since it gives the firm options in responding to uncertain events, such as changes in government policies, competitors' reaction, market conditions and exchange rates. These points will be elaborated in Section 3.

(d) Currency Area Hypothesis

The role of exchange rates in the locational decision of MNEs is acknowledged by many

economists. As will be discussed in the next section, the volatility of the exchange rate will increase the value of overseas operations and, as a result, enhance FDI outflows. Yet, it is only comparatively recently that the relationship has been systematically explored using macro-economic data.

Aliber (1970, 1993) has long argued that the pattern of FDI can be explained in terms of the existence of different currency areas. Some currencies are regarded as 'hard', and carry a premium over weaker currencies. Aliber posits that portfolio investors are likely to ignore the exchange rate risk on the foreign earnings of a firm. As a result, firms from harder currency areas are able to borrow at lower costs and capitalise the earnings on their FDI in weaker currency areas at higher rates than local firms. The higher the share of capital in value-added and scale of the currency premium, the greater the comparative advantage of FDI a foreign investor can enjoy over firms in the host economy.

This hypothesis is not been strictly empirically tested. However, many economists are well aware that the overvaluation of a currency is associated with outflows of FDI and vice versa. It is demonstrated by the historical experiences of several countries with significant outward FDI outflows: the U.S. in the 1950s and 1960s, West Germany in the 1970s, and Japan in the late 1980s. However, other explanations account for the experiences of these countries. A currency devaluation lowers the costs of production of the country, raising the profitability of FDI inflows into that area. The wealth effect is another explanation by which appreciation of the source currency could increase FDI (Froot and Stein 1991).

There are several critical shortcomings of the currency area hypothesis. First, it cannot explain mutual foreign investments between two countries belonging to different currency areas, as it posits only one-way FDI flow from harder to softer currency areas. Secondly, the hypothesis cannot explain FDI flows within the same currency areas. As South East Asia, for example, substantially belongs to a U.S. dollar currency area (Frankel and Wei 1994, Goldberg and Klein 1997), the hypothesis cannot explain US FDI inflows into this area. This shortcoming should be well explained by managerial flexibility, which this study emphasises. Thus, the currency area hypothesis provides an incomplete explanation of FDI in general.

(e) Managerial Flexibility in International Operations: A Neglected Factor?

As is briefly reviewed above, in the theories of FDI, a central attention has been paid to the various factors that may bring a multinational enterprise to 'success' in foreign markets. In existing literature on FDI and multinational enterprises, a number of multinationals appear to pursue a haphazard approach to overseas expansion; however, there is invariably an underlying rationale. Generally, this involves understanding and capitalising on those factors that led to success in the past. The imperfections of the market, for example, include barriers to entry, product differentiation, and control of raw materials, patents, know-how, trademarks, marketing, and organizational skills.

These perspectives may, however, lose considerable relevance in part for the investigation of the economic and competitive behaviour of an internationally operating firms. The neglected factor is definitely managerial flexibility, in which a multinational enterprise can take advantage of its global network. As is clearly pointed out by Buckley and Casson (1998) recently, "Flex-

ibility is identified as the hallmark of recent modelling of the multinational enterprise. The focus on flexibility is a response to the rationalization and restructuring of international business, which has occurred since the end of the golden age (P.21)".

The emphasis on managerial flexibility in international business does not necessarily deny relevance of the classic FDI theories and, therefore, it should make a supplementary contribute to theorising the motivation of FDI by an international firm. However, while the traditional theories are to explain the foreign market entry decision, the nature of flexibility is likely to emphasise FDI as a sequence and dynamic optimising behaviour of a international firm. Then, the characteristics of the decision-making based on managerial flexibility are well modelled by a real options setting (Trigeorgis 1996, for example). In the next section, we examine in detail how managerial flexibility may well explain a real world of FDI and how to model it.

3. FDI AS A REAL OPTION

It appears that the strategic management literature often encourage the managers in multinational enterprises to adopt strategies that provide operational flexibility in its global business. For example, multiple sourcing relationships allow international firms to mitigate losses that stem from unanticipated changes in input costs in a particular country or from adverse exchange rate movement. Firms are also 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, which is well-known as the just-in-time system employed Japanese auto industry.

Flexibility is desirable in the face of future uncertainty, while making investment in flexibility is a resource-allocation decision. As with all resource-allocation problem, the crucial question is whether committing scarce resources to acquire certain types of flexibility will result in substantial increases in expected value of the organisation. In this respect, to theorise managerial flexibility should require examining dynamic nature of the firm. The theory may focus on the uncertainty which is generated by volatility in the international business environment. To cope with volatility, company's strategy can be achieved by several strategic options, including FDI.

A real option approach to FDI emphasises the value of operational flexibility of MNEs in order to benefit from becoming global (Kogut 1983, Kogut and Kulatilaka 1994a, 1994b). There are many sources of environmental uncertainty, such as exchange rate volatility, new product entry, changes in government policies, the emergence of new international competitors and so on. If the firm is risk-averse, these uncertainties will discourage it from investing abroad. The real options theory of FDI postulates, however, that these uncertainties can increase the value of FDI. The theories we reviewed earlier do not analyse the importance of a multinational network as a potential determinant of the likely conduits of FDI.

Based on these arguments, this section examines the characteristics of decision-making of an international firm which faces stochastic movements of exchange rates. Specifically, the following two questions are examined. First, how static investment valuation, as will be named as the Marshallian threshold, may be inadequate for the task of project valuation. Secondly, how a combination of managerial flexibility and uncertain environment increase the value of firm?

Despite its mathematical guise, the real options approach stems from elaborate observations

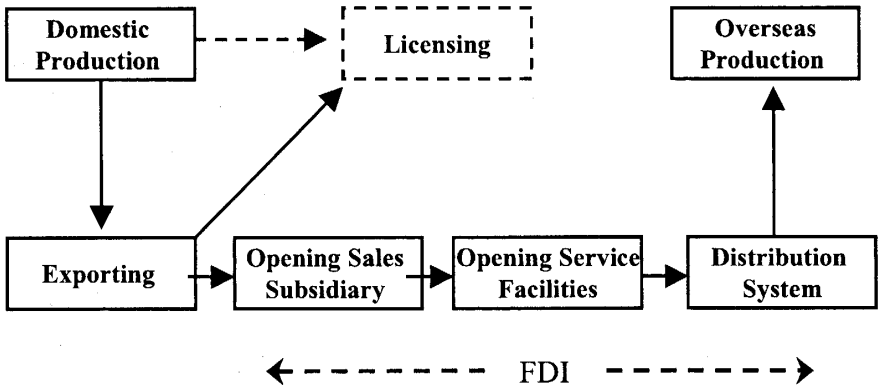

Fig. 1 FDI as a Sequential Process

of the actual FDI process. A dynamic view of corporate internationalisation is a sequential process. A firm moves through exporting to the setting up of a foreign sales subsidiary, to licensing agreements and similar contracts before actual direct investment takes place. The typical sequence of overseas expansion is depicted in Fig. 1. This step-wise approach functions as a risk-minimising strategy in an uncertain foreign environment.

Moreover, as was discussed in the previous section, FDI flows are largely incremental investment in already established subsidiaries. The recent trend of increasing intra-firm trade suggests that the coordination of a network of subsidiaries dispersed throughout the world provides operational flexibilities that benefit MNEs. In light of the risk-minimising, incremental, and flexible nature of FDI, conventional theories of FDI that emphasise internalisation and market imperfections provide an incomplete picture of FDI.

The real options approach to FDI has never been seriously criticised. On the contrary, many FDI researchers admit the significance of uncertainty, flexibility, and dynamism in international business and recognise the need for a new agenda to explain a sequential FDI process. Buckley and Casson (1998), for example, note that 'the classic application of the traditional agenda is to the foreign market entry decision. This (new) agenda recognises change, but interprets it as a sequence of independent one-off events, rather than as a continuous systemic process.... the models of market entry developed in the 1970s remain too static to address the crucial issues of the 1990s, because they fail to take proper account of volatility' (p.22).

(a) THE MODEL

This section examines the value of foreign direct investment (FDI) when an investing company faces the risk of exchange rate fluctuations. FDI can be understood as a managerial advantage of flexibility in a global operating network system, encompassing export and foreign investment. Clearly, the coordination of a network of subsidiaries dispersed throughout the world provides an operating flexibility that adds value to the company. A switch in production is one possible option in response to uncertain events such as exchange rate volatility. When the exchange rate appreciates, FDI becomes advantageous as a means of avoiding larger decrease in profit. Our model shows that, by a switching option, FDI becomes more valuable when the volatility of the exchange rate increases.

Consider an international firm based on the home country. The firm currently produces a fixed volume of product and raises the profit by exporting it. The revenue from export is exposed to exchange rate fluctuations; therefore, the profit is volatile to change of the exchange rate. Then, the firm is now consider investing in a production project in a foreign country. A merit of the foreign investment is to keep the flow of profit more stable. Thus, the firm's investment opportunity is analogous to a perpetual call option; the right but not the obligation to sell a share of stock at a pre-determined price. It is assumed that the firm is to maximise the value of the firm itself in terms of foreign currency. Furthermore, as the firm's managerial resource is limited, the two operations, i.e. export and overseas production, will be mutually exclusive to conduct.

The firm's strategy consists of a pair of decisions to switch between these two. In the exporting state the firm has a put option to start overseas production. The firm can suspend exporting and exercise the option to invest when exchange rate is getting appreciated. This gets it the constant flow of operating profit in terms of foreign currency. Our task is to find the rules for optimal exercise of the switching option between export and FDI.

We start the analysis by assuming that the firm has already started the operation in home country and export all of the product. The quantity and the price of firm's product are assumed to be constant and, as a result, the profit from export decreases by currency appreciation. The profit function is now assumed to appear in a linear form, $P_t = aX_t - Z$, where P_t and X_t are the profit and the exchange rate at time t, respectively, a and Z are constant. Then, the value of the exporting firm is calculated as

$$(1) \qquad \Pi_t^e = \frac{aX_t - Z}{\rho}$$

where ρ is the cost of capital.

The firm has a managerial flexibility to invest in overseas operation to avoid the downside risk due to exchange rate fluctuations. We assume that the project requires an initial investment I, and yields a constant return R, both denominated in the foreign currency. The value of the firm by gains from overseas operation is R/ρ in foreign currency term. Then, we define the general value function of the firm as follows,

$$(3) \qquad G(X_t) = \begin{cases} aX_t - Z/\rho & for\ X_t > \overline{X} \\ R/\rho & for\ X_t \leq \overline{X} \end{cases} .$$

where $\overline{X}$ is the traditional Marshallian threshold exchange rate, which is derived from a simple NPV calculation. In other word, this presents a critical level of switching exchange rate at which the firm decides to invest. On the other hand, the firm should withdraw overseas operation if exchange rate exceeds this. As is easily calculated as $\overline{X} = (Z + R - I)/a$. Obviously, the function $G(X_t)$ represents the value of the firm under the deterministic environment.

(c) EXCHANGE RATE UNCERTAINTY

In a real world, the firm is rational in expecting the probabilistic motion of exchange rate in the future. In option thinking, it could be optimal for a firm to wait for investing since the exchange rate may move back. As a result, a stochastic threshold exchange rate, defined here as

X^*_t, can be different from the one obtained by the Marshallian principle. We now examine how, under uncertain conditions, the stochastic threshold exchange rate should be different from the traditional Marshallian one.

The profit is risky since the exchange rate fluctuates randomly. In particular, we put the assumption that the value of domestic currency in terms of one unit of foreign currency follows geometric Brownian motion of the form

$$(2) \qquad \frac{dX_t}{X_t} = \theta\, dt + \sigma\, z_t$$

where θ is a constant drift parameter of exchange rate, σ is a constant proportional variance parameter, and z_t is a standard Wiener process.

(d) OPTION VALUE FUNCTION

By following the formulation of McDonald and Siegel (1986), we define the value of the switchable project, i.e. the value of the option, as $V(X_t)$. This implies that the switchable operation can be seen as a derivative asset whose dollar value is $G(X_t)$, which is stochastically determined.

We assume that the firm is risk-neural. Moreover, the stochastic fluctuation in exchange rate is spanned by other assets in the foreign market, implying that investing one unit of foreign currency in the foreign risk-free asset yields an instantaneous dollar income of rX_t, where r is a positive constant risk-free interest rate in the foreign money market. By Ito's Lemma, the change in the value of the international switching operation must satisfy

$$(4) \qquad dV = V_x dX + \frac{1}{2}\sigma^2 X^2 V_{XX}\, dt$$

where $V_x = \partial V/\partial X$ 1 and $V_{xx} = \partial^2 V/\partial X^2$. Thus, the following differential equation must be satisfied by the function $V(X_t)$ in equilibrium:

$$(5) \qquad \frac{1}{2}\sigma^2 X^2 V_{XX} + \theta X V_x - \rho V = 0.$$

Then, we obtain the general solution[3]

$$(6) \qquad V(X) = A_1 X^{\alpha_1} + A_2 X^{\alpha_2}$$

where A_1 and A_2 are constant and to be determined from the relevant boundary conditions. α_1 and α_2 are, respectively, the positive and negative roots of the quadratic expression associated with the general solution to Eq. (6). They are expressed as follows[4]

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[3] To obtain the general solution follows the normal replication formulated in Black and Scholes (1973), Sick (1995) and, by using the risk-neutral valuation, Cox and Ross (1976).

[4] See McDonald and Siegel (1986).

$$\alpha_1=\frac{1}{2}-\frac{(\rho-\delta)}{\sigma^2}+\sqrt{\{\frac{(\rho-\delta)}{\sigma^2}-\frac{1}{2}\}^2+\frac{2\rho}{\sigma^2}} \quad >1$$

$$\alpha_2=\frac{1}{2}-\frac{(\rho-\delta)}{\sigma^2}+\sqrt{\{\frac{(\rho-\delta)}{\sigma^2}-\frac{1}{2}\}^2+\frac{2\rho}{\sigma^2}} \quad <0$$

where $\delta \equiv r+\beta \times RiskPemium=\rho-\theta$[5].

The boundary conditions are given by plausible economic interpretations. If X_t is at a very low level, the probability to reach the threshold exchange rate to switch operation from export to foreign investment is very small. Therefore, the option value of this case should be worthless, implying $A_2=0$. Then, the general solution can be rewritten as

(7) $\quad V(X)=A_1X^{\alpha_1}=AX^{\alpha}$

in which, for simplicity, we redefine as $A_1=A$, $\alpha_1=\alpha$. This presents the value of an investment opportunity, depending on the exchange rate the firm currently faces.

The stochastic threshold exchange rate (X^*) has been defined as the trigger rate at which the firm switches its operation modes under exchange rate uncertainty. To determine this, the value-matching and smooth-pasting conditions require respectively

(8) (9) $\quad V(X_t^*)=G(X_t^*)-I \qquad V'(X_t^*)=G'(X_t^*)$.

From these conditions, A_1 and X^* are determined.

(e) ANALYTICAL RESULT

Now we examine the characteristics of the optimal investment rule and the value of the investment opportunity. From Eq. (8) and (9), the stochastic threshold X^* is expressed as

(10) $\quad X^*=(\frac{\alpha}{\alpha-1})(\frac{Z+R-I}{a})=(\frac{\alpha}{\alpha-1})\overline{X}$.

Obviously, $X^*>\overline{X}$ is obtained, which implies that the effect of uncertainty may defer the timing of investment. The solution for $V(X_t)$ is obtained as the following specific form

(11) $\quad V(X)=\frac{a}{\alpha\rho}(\frac{\alpha}{\alpha-1}\overline{X})^{1-\alpha}X^{\alpha_1}$.

Fig. 2 show the functions of $G(X_t)$ and $V(X_t)$, both depend on the exchange rate at time t. The critical value X^* is optimal to invest. Now we examine the characteristics of this solution. An important point is that since $\alpha>1$, $X^*>\overline{X}$. As McDonald and Siegel (1986) demonstrate theoretically, since future values of exchange rate are unknown, there is an opportunity cost to investing immediately. Hence, the optimal investment rule is to invest when exchange rate X_t is at least as large as a critical value of X^* that exceeds $\overline{X}$. Thus, the simple Marshallian rule is

[5] See McDonald and Siegel (1986) p.175-6.

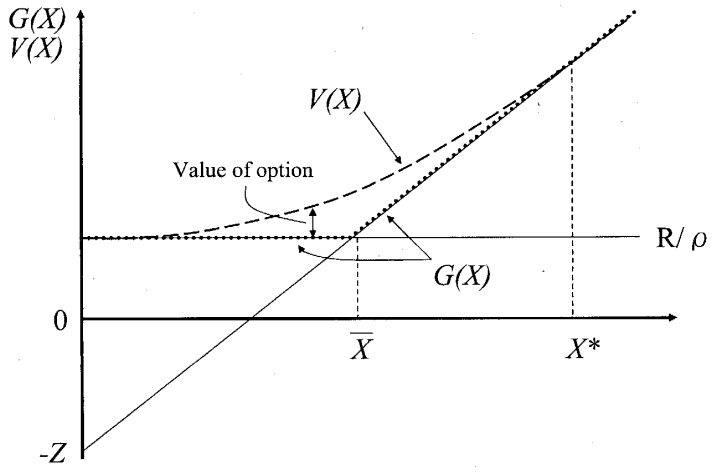

Fig. 2 The Functions of $G(X)$ and $V(X)$

incorrect; uncertain derives a gap between the critical exchange rate and X^* and $\bar{X}$. The size of the gap is $\alpha/(\alpha-1)$, and it becomes important to examine its magnitude for realistic value of the underlying parameters, and its response to changes in these parameters.

We are interested in how the changes in parameter values affect the threshold exchange rate. In order to focus on the characteristics in equilibrium, it is analytically convenient to exclude the driving trend factors in the movement of exchange rate. This requires $\theta=0$, in which the level of exchange rate may move randomly but its mean value keeps constant in the long run. Then, the following results are obtained.

$$(12)\quad \partial\bar{X}/\partial I = 1/a > 0$$

$$(13)\quad \partial X^*/\partial I = a\alpha/(\alpha-1) > 0$$

$$(14)\quad \partial\bar{X}/\partial\sigma = 0$$

$$(15)\quad \partial X^*/\partial\sigma = \partial X^*/\partial\alpha \;\; \partial\alpha/\partial\sigma > 0$$

$$(16)\quad \partial\bar{X}/\partial\rho = 0$$

$$(17)\quad \partial X^*/\partial\rho = \partial X^*/\partial\alpha \;\; \partial\alpha/\partial\rho < 0$$

The economic implications of these results will be discussed in detail with numerical examples in the next section.

4. NUMERICAL EXAMPLES

McDonald and Siegel (1986) plug numerical values into their model and report how the value of the option to invest and the optimal investment strategy depend on the state variables and the parameters. Following their methodological procedure, some numerical examples will help us understand the characteristics of the results and show how the threshold exchange rate depends on the values of the parameters. The numerical results share the same characteristics as we examined in the comparative static analysis in the previous chapter and, furthermore, intuitively understandable by implications of standard option pricing models.

Table 1 Value of Investment Opportunity V(X)*

Exchange Rate (X)	Sigma (σ)				
	0.1	0.2	0.3	0.5	G(X)
	V (X)				
0	25.00	25.00	25.00	25.00	-792
5	25.00	25.14	26.20	32.49	-708
10	25.01	26.09	30.55	47.71	-625
15	25.11	28.69	38.58	68.44	-542
20	25.54	33.75	50.63	93.83	-458
25	26.82	42.10	66.95	123.36	-375
30	29.90	54.55	87.74	156.68	-292
35	36.30	71.92	113.18	193.52	-208
40	48.32	95.04	143.41	233.65	-125
45	69.18	124.72	178.58	276.93	-42
50	103.25	161.79	218.80	323.18	42
55	156.22	207.07	264.19	372.31	125
60	235.37	261.38	314.85	424.18	208
65	349.75	325.54	370.88	478.73	292
70	510.44	400.36	432.36	535.84	375
75	730.78	486.68	499.39	595.47	458
80	1026.64	585.31	572.04	657.52	542
85	1416.65	697.07	650.39	721.95	625
90	1922.51	822.78	734.50	788.69	708
95	2569.23	963.27	824.46	857.70	792
100	3385.42	1119.35	920.32	928.92	875
105	4403.58	1291.85	1022.15	1002.31	958
110	5660.40	1481.58	1130.01	1077.83	1042
115	7197.06	1689.38	1243.96	1155.44	1125
120	9059.54	1916.04	1364.05	1235.10	1208
125	11298.91	2162.41	1490.34	1316.78	1292
130	13971.67	2429.30	1622.89	1400.44	1375
X^*	58.00	71.00	87.00	127.00	

* ρ=0.12, a=2.0, Z=20, R=100, I=25

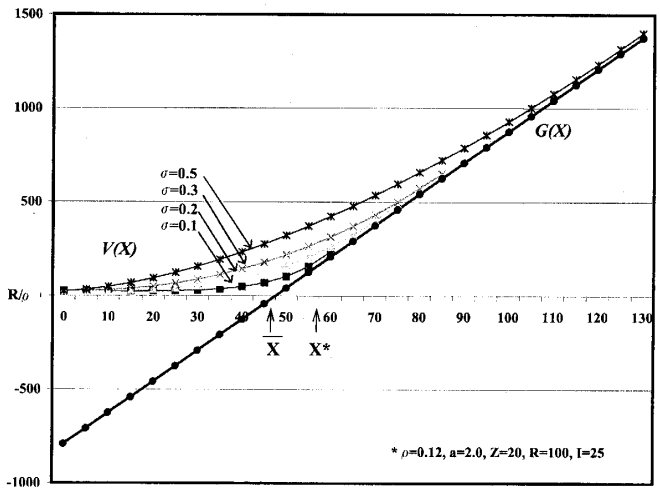

Fig. 3 Value of Investment Opportunity, V(X) (σ=0.1, 0.2, 0.3, 0.5)

We choose, for the present, a basic scenario which consists of the following set of values[6].

Volatility of the exchange rate per annum; $\sigma = 0.1$

The investment cost; $I = 25$

The cost of capital; $\rho = 0.12$

As for σ, 0.1 implies that the standard deviation of the change of exchange rate is about 10% on average, which is highly possible. Another parameter, the cost of capital $\rho = 0.12$, seems to be given reasonably. Table 1 and Fig. 3 show the value of the option of the switching operation and the threshold exchange rates. It is easy to see that, in this basic scenario, the stochastic threshold exchange rate (X^*) is 58, while the Marshallian threshold exchange rate ($\overline{X}$) is 47.5. Thus, the traditional Marshallian rule, which tells us that the firm should invest when exchange rate reaches $\overline{X}$, is clearly misleading. Under the stochastic optimisation, the threshold exchange rate is X^*, which is larger than $\overline{X}$.

Let us first examine the effect of the volatility σ on the option value. The results are presented in Table 1 and Fig. 3 In option models, σ is always positively correlated with the option value. Our results confirm this. This nature of option value is due to the asymmetry of the risk in which the owner of a real option can infinitely benefit from the upside potential of the underlying asset. 'Asymmetry of the risk' is explained as follows. Higher volatility of the exchange rate can generate, in our switching model, a relatively high probability for larger upward moves, i.e. depreciating of domestic currency, that increases the profit from export. On the other hand, the downside risk can be limited by exercising overseas investment the profit of which constantly assures as much as R/ρ. This implies that, if necessary with the investment cost I to incur, the profit from the switchable international operation R/ρ is at least assured. In this situation, when σ is large, this increases the probability of X exceeding X^* and of receiving the final profit. As a result, the value of $V(X)$ will be naturally increased. In other words, when X is

[6] We also set the other parameter values, unless otherwise noted, as $a = 2$, $Z = 20$, $R = 100$.

Table 2 Value of Investment Opportunity V(X)*

Exchange Rate (X)	Investment Cost (I)					
	I = 25		I = 40		I = 60	
	V(X)	G(X)	V(X)	G(X)	V(X)	G(X)
0	25.00	-792	40.00	-667	60.00	-500
5	32.49	-708	48.30	-583	69.87	-417
10	47.71	-625	65.17	-500	89.91	-333
15	68.44	-542	88.16	-417	117.23	-250
20	93.83	-458	116.31	-333	150.68	-167
25	123.36	-375	149.05	-250	189.59	-83
30	156.68	-292	185.98	-167	233.49	0
35	193.52	-208	226.82	-83	282.02	83
40	233.65	-125	271.32	0	334.90	167
45	276.93	-42	319.29	83	391.91	250
50	323.18	42	370.57	167	452.85	333
55	372.31	125	425.03	250	517.57	417
60	424.18	208	482.54	333	585.92	500
65	478.73	292	543.01	417	657.77	583
70	535.84	375	606.33	500	733.03	667
75	595.47	458	672.43	583	811.58	750
80	657.52	542	741.22	667	893.33	833
85	721.95	625	812.65	750	978.22	917
90	788.69	708	886.64	833	1066.15	1000
95	857.70	792	963.14	917	1157.07	1083
100	928.92	875	1042.10	1000	1250.90	1167
105	1002.31	958	1123.46	1083	1347.59	1250
110	1077.83	1042	1207.19	1167	1447.08	1333
115	1155.44	1125	1293.22	1250	1549.33	1417
120	1235.10	1208	1381.53	1333	1654.28	1500
125	1316.78	1292	1472.08	1417	1761.89	1583
130	1400.44	1375	1564.83	1500	1872.11	1667
X*	127.00		107.00		80.00	

* ρ=0.12, α=2.0, σ=0.5, Z=20, R=100

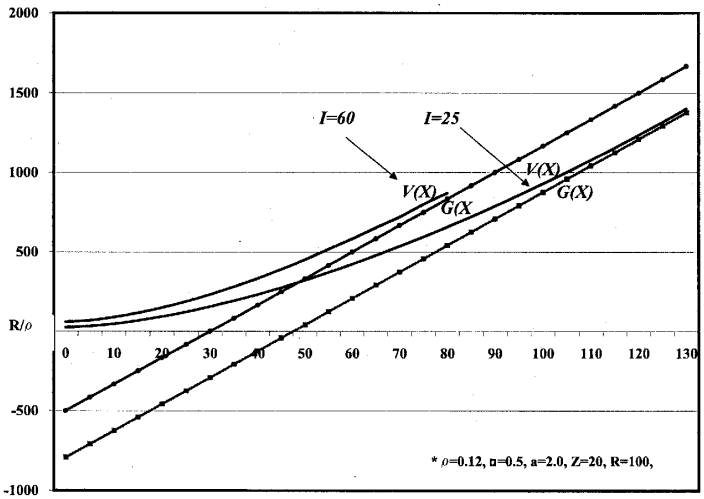

Fig. 4 Value of Investment Opportunity, V(X) ($I = 25, 60$)

higher, the probability of receiving nothing is small and, therefore, additional upward potential of X value does not cause such an immense increase in $V(X)$.

Next, we turn to examine the effect of the change in investment cost (I). The results are given in Table 2 and Fig 4. It is obvious that the option is worth more when the current value of a completed project is high. If $V(X)$ is high, then the expected payoff at completion is high as well, and everything else being equal, this claim is worth more. There is a clear reason for a negative correlation between the option value and the total amount of investment cost (I). Consider two investment projects with the same expected final payoff. If you have to invest more money in one of these projects, this will necessarily be worth less than the other one, because the cost of acquiring the final payoff is higher. Therefore, as an investor would prefer a project with a small investment cost I, it takes a larger payoff for a larger X^* to make the investor indifferent to invest in the latter.

Finally, although it is not explicitly shown in the tables and figures, an increase in ρ reduces the threshold value X^*. The economic implication of this is rather complicated. As Majd and Pindyck (1987) point out, ρ is an opportunity cost of investment, which can be distinguished into two components. One component of the full cost is indeed the cost for delaying investment, and thus ρ lowers the investment threshold. However, further costs are necessarily incurred because of the timing required to complete construction. During the minimum time to build, the investor can benefit from capital gain from profit, but does not receive the dividend of profit multiplied by ρ. This dividend grows with X at a rate ρ. This cost increases with ρ and reduces the final profit. Therefore, a higher Xt is required to trigger an investment.

5. SUMMARY AND CONCLUSION

Based on a critical survey in the existing literatures on FDI, this study focuses on the role of managerial flexibility of an international company. A multinational enterprise is, by definition, a

network of activities based in several countries. The global networks should function as managerial flexibility of international operations and derive benefit from uncertain events such as demand shifts and exchange fluctuations. In this study, a real option model is employed to examine how managerial flexibility affects the value of an international firm. FDI is analogous to a put option when the company faces downside risk of exchange rate changes. Therefore, a multinational enterprise can increase the value of the option by switching the operations between export and overseas production.

The results of the model suggest that increased volatility in exchange rate increases the value of the option to postpone investment abroad. This appears, in our model, as the gap between the Marshallian and stochastic threshold exchange rates. This study also indicates that the greater the volatility of exchange rate, the greater the value of the multinational enterprise who possesses a switchable option. Thus, we reach the conclusion that a multinational enterprise should recognise that investments in more than one country or in different locations are valuable when business environments are changing.

Our argument has been based on real option thinking to explain FDI motivation. It is reasonable to believe that this approach provides an useful analytical framework. However, the real options approach has not yet been fully formalised. Moreover, this approach will not replace traditional FDI theories. It can explain the risk-minimising motivation and potential benefits to invest overseas; however, it may not say why the firm chose to locate in Malaysia, for example, instead of Thailand. To explain such details, the O-L-I approach still overbears it. Thus, the real options approach necessarily calls for complementary explanations of FDI issues.

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