

ESSAYS ON THE THEORY OF INVESTMENT  
SUBSIDY



Pei Yang

A thesis submitted for the degree of Doctor of Philosophy in Finance

Essex Business School

University of Essex

2016

To My Mother

## **Acknowledgements**

I would like to express my deepest gratitude to my supervisor, Dr Norvald Instefjord, for his care, support, guidance, and advice throughout my doctoral years. I sincerely appreciate his guidance and help during writing and revising this thesis. His comments and suggestions are always enlightening. His patience and carefulness in research really impress me. My sincere gratitude also goes to my supervisor, Dr Vivekanand Nawosah, for his help and support during the last two years of my PhD. I also would like to thank him for his insightful comments and suggestions on writing and revising this thesis. I am so lucky and really honoured to work with them during my PhD study.

Special thanks go to my friends, Xinyang Luan and Xiaoran Yang, who always cheer me up and encourage me whenever I need it.

Above all, I would like to thank my mother, Mrs Yun Zhang, who gave birth to me, raised me up, taught me through her own words and deeds, and encouraged me to pursue my dreams. I am forever indebted for her unconditional and consistent love and support. This thesis is dedicated to her.

# Contents

<b>Abstract</b>	<b>iv</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Research Questions . . . . .	1
1.2 Contributions . . . . .	9
1.3 Existing Literature . . . . .	12
1.3.1 Investment Timing . . . . .	12
1.3.2 Entry Modes . . . . .	14
1.3.3 Real Options . . . . .	17
1.3.4 Investment Incentives . . . . .	24
1.4 Overview of Remaining Chapters . . . . .	28
<b>2 Investment Subsidy</b>	<b>30</b>
2.1 Introduction . . . . .	30
2.2 Framework . . . . .	36
2.2.1 Investment and Earnings . . . . .	37
2.2.2 Investment Subsidy . . . . .	38
2.2.3 Timing of Subsidy . . . . .	39
2.2.4 Preemption Risk . . . . .	41

2.3	Theoretical Results . . . . .	42
2.3.1	Optimal Subsidy Design . . . . .	42
2.3.2	Optimal Timing of Subsidy . . . . .	54
2.3.3	Preemption Risk . . . . .	57
2.4	Empirical Predictions for FDI Subsidy . . . . .	63
2.4.1	Industry-Related Subsidy Effects . . . . .	63
2.4.2	Subsidy Market-Related Effects . . . . .	64
2.5	Conclusion . . . . .	66
2.6	Appendix . . . . .	68
2.7	Guide to Notation . . . . .	72
<b>3</b>	<b>Mode of Entry</b>	<b>75</b>
3.1	Introduction . . . . .	75
3.2	Unsubsidised Investment . . . . .	81
3.2.1	Joint Venture . . . . .	83
3.2.2	Wholly-Owned Subsidiary . . . . .	85
3.2.3	Welfare . . . . .	87
3.2.4	Optimal Unsubsidised Investment . . . . .	89
3.3	Subsidised Investment . . . . .	90
3.3.1	Investment Subsidy . . . . .	90
3.3.2	Optimal Mode of Entry . . . . .	96
3.3.3	Knowledge Transfer Benefits . . . . .	102
3.4	Empirical Implications . . . . .	104
3.5	Conclusions . . . . .	105
3.6	Appendix . . . . .	107

3.7	Guide to Notation . . . . .	112
<b>4</b>	<b>Competitive Product Markets</b>	<b>115</b>
4.1	Introduction . . . . .	115
4.2	Competitive Product Markets . . . . .	120
4.3	Unsubsidised Entry and Exit . . . . .	123
4.3.1	Optimal Entry and Exit . . . . .	123
4.3.2	Welfare in Competitive Industries . . . . .	127
4.4	Subsidised Mode of Entry . . . . .	129
4.4.1	Optimal Subsidy and Optimal Timing . . . . .	129
4.5	Conclusions . . . . .	135
4.6	Appendix . . . . .	137
4.7	Guide to Notation . . . . .	141
<b>5</b>	<b>Conclusions</b>	<b>144</b>
	<b>References</b>	<b>148</b>

# Abstract

In this thesis, we investigate a firm's investment timing decision and choice of market entry mode under uncertainty and irreversibility. We investigate how a host country can affect the firm's investment decisions through providing investment incentives. The real options approach to valuation is applied, and three main theoretical contributions are provided in this thesis.

First, we derive the optimal form of subsidy package and find that the optimal subsidy package should always compensate the firm for giving up the investment opportunity and making the investment immediately. By making a trade-off between the host country's incremental welfare benefits and the costs of the subsidy package, we obtain the optimal timing to provide it. We also examine the effects of preemption risk on the timing of investment and the value of a subsidy package.

Second, we consider the timing of investment and the choice of entry modes. We evaluate the investment projects and derive the investment thresholds when the firm can choose between a joint venture (JV) and a wholly-owned subsidiary (WOS). We find that when there is no subsidy offered, the firm prefers a WOS, while the host country prefers a JV. When there are subsidies offered by the host country, we find that both the firm and the host country prefer a WOS. A JV will be preferred only if it has some distinctive welfare benefits that are not associated with a WOS, for instance knowledge transfer benefits.

Last, we introduce product market competition into the problems of investment timing and choice of entry mode. We find that competition will not alter the conclusions we have obtained. The optimal mode of entry is a WOS, unless a JV has some distinctive welfare benefits that cannot be provided by a WOS.



# Chapter 1

## Introduction

### 1.1 Research Questions

Investments that have externalities lead to incentives of third parties to influence the decision-making process of the party who owns the investment opportunity. This idea is prominent in the work of Coase (1960) who argued that, in a world where individuals' rights are well defined by law, it is possible to sue successfully for damages when investments with negative externalities are being made. This will impose costs on the individual who makes the investment decision, and in a perfect world, the decision maker will internalise exactly the cost of the externality, and the socially efficient investments will be made even without interference from the government. This thesis presents the case in which investments have positive externalities, and the problem is that too few investments are being made or that they are being delayed because the decision maker is unable to internalise the externality. Investment incentive is one way to internalise the externality, and this thesis examines the optimal choices when it comes to timing, form, and targeting investment incentives. This is the fundamental research question that is addressed.

The area in which positive externalities are the most prominent is the area of foreign direct investments (FDIs), and the thesis presents and examination of models of subsidy for such investments. The problem is, however, considerably broader than that, and as an example, we can point to green investments as an area of growing interest. A green investment is an investment that replaces a traditional technology with a new one that is less damaging for the global climate. Thus, green investments have considerable positive externality on top of the intrinsic commercial value. Incentives to promote green investments will, therefore, have the same structure as incentives to promote FDI.

During the last several decades, with the process of globalisation and gradual elimination of trade and investment barriers, it has become increasingly convenient and profitable for enterprises to make investments in foreign countries. At the same time, host countries are more open to FDIs. Through FDI, a firm can either replicate its home country-based business in a foreign country to locate production nearer to its customers, or it can locate some stages of its business in a foreign country to take advantage of the differences in factor prices. A host country can also benefit from FDIs in many ways. Investment from abroad not only means the influx of external capital and the increase in employment opportunities and tax revenues from the new businesses but also involves the transfer of advanced technology, expertise skills, and management methods. Competition from new businesses may lead to greater productivity and efficiency in the relevant industry of the host country. The corporate governance standards of the host country may also be improved. Essentially, a host country can boost its economic development and improve social welfare through FDI. Therefore, it is often motivated to offer various investment incentives to attract FDI.

Many countries have established specialised agencies to promote and incentivise FDIs. The FDI incentives can take various forms but are broadly fiscal or financial in nature and can

be categorised into two major types: tax relief to reduce a firm's tax burden and investment support to subsidise a firm's investment cost. The former includes a low corporate tax or individual income tax rate, tax holidays, accelerated depreciation allowances on capital taxes, and other types of tax concessions, and the latter includes infrastructure subsidies, investment financial subsidies, free land or land subsidies, and soft loans or loan guarantees.

Buckley and Casson (1998) suggested that when firms make FDI decisions, some fundamental issues must be considered, such as the reason to enter a market, when to invest, which entry mode to choose, and how to build it. The timing of investment is one of the central concerns of decision makers within a firm. However, Rivoli and Salorio (1996) suggested that rich explanations have been offered to the 'why', 'where', and 'who' of FDI (see e.g., Dunning, 1988a; Dunning and Rugman, 1985). However, only a limited amount of literature considers the 'when' of FDI (see e.g., Buckley and Casson, 1981; Casson, 1994). Among the existing literature considering FDI timing, the timing of investment is often treated as exogenously given or analysed in a deterministic model. Given the importance of the timing issue and the fact that the existing literature can only partially explain it, our first set of research questions relate to the timing of investment and how a host country can affect it using investment incentives.

Although it has become much easier nowadays for firms to invest globally, firms still face great uncertainty when investing in a foreign country. Dixit (1989) and Kogut (1991) introduced market uncertainty, such as unstable revenue, changing product price/investment cost, and evolving technology. Henisz (2000) pointed out the institutional uncertainty that arises when firms invest in a foreign country with different regulatory policies, laws, and political systems. It is difficult for a firm to predict the economic and political prospects of a foreign country and the costs used to set up the investment may be more difficult to recover

in an unfamiliar place. Under the conditions of uncertainty and irreversibility, a firm should have some flexibilities in the timing to make the investment and enter a new market.

From a firm's point of view, if it makes the investment immediately and the future market conditions improve, an early investment may lead to a higher market share and more revenues, which is often referred to as the 'first-mover advantage'.<sup>1</sup> However, if the future market conditions deteriorate, the firm may suffer a great loss and it may be difficult to recover its investment costs. If the firm chooses to postpone the investment and wait until the market conditions become clearer, the 'first-mover advantage' may vanish and the firm can only obtain a lower market share and less revenues. Therefore, the firm needs a reasonable decision rule on when to make the investment and enter a new market. From a host country's point of view, the early arrival of the investment can result in incremental tax revenues, employment opportunities, and social welfare benefits. The host country also needs to take into account the effect of the competition that is brought by foreign firms to the domestic industry. Therefore, the study of optimal timing of investment is also of great importance to the host country.

Decision makers of the host country should necessarily know the factors that can affect a firm's investment decisions and be aware of the costs and benefits associated with them. A host country can attract investment through providing a subsidy package, which consists mainly of tax relief and investment support. It can further influence a firm's investment decisions through adjusting the value of the subsidy package. This is a distinctive feature of our analysis in this thesis. Previous literature on subsidies has often analysed static models, that is, once offered, the subsidies are treated as constants (see e.g., Pennings, 2000, 2005;

---

<sup>1</sup>Lieberman and Montgomery (1988) stated that the three primary sources of first-mover advantages are technological leadership (see e.g., Michael, 1981) preemption of scarce assets (see e.g., Main, 1955; Prescott and Visscher, 1977; Schmalensee, 1981), and switching costs/buyer choice under uncertainty (see e.g., Klemperer, 1986; Ries and Trout, 1986)

Yu, Chang, and Fan, 2007; Danielova and Sarkar, 2011). The firm and the host country maximise their profits/benefits given these constant subsidies.

In contrast, our analysis is conducted under a dynamic setting. We argue that the host country can affect the firm's investment decision through adjusting the value of the subsidy package. In other words, the value of the subsidies can vary according to market conditions or the desired timing of the host country. The increase or reduction in subsidies can be regarded as a 'reward' for speeding up the investment or a 'penalty' for delaying the investment. The host country should ideally know the optimal value of subsidy package to maximise its own benefits. Since it is the firm's right to decide when to make the investment, it must always be optimal for the firm at the time of investment. Since the host country can adjust the value of the subsidy package, it should also be optimal for the host country at the time of investment. In the following chapters, we look at the optimal value and timing of the subsidy package that needs to be offered by the host country to induce the investment to take place at its desired timing.

When the investment payoff is uncertain and the investment cost is irreversible, it is better for investors to adopt a wait-and-see strategy and postpone the investment. In this situation, the theory of real options applies. McDonald and Siegel (1986) introduced the concept of 'the value of waiting'. They reached a fundamental conclusion that, under uncertainty, deferring the investment can enhance its expected value. When the value of waiting exceeds the benefits from making the investment, the expected value of the investment always increases with delaying. In investment under uncertainty, in other words, the real options approach was summarised by Dixit and Pindyck (1994). In the following analysis, we employ the standard real options model in the case of a foreign monopolist investing in a single host country. When the strategic interactions among market participants are taken into account,

we apply the real options game model to account for the effects of preemption risk.

Many studies on the timing of investment under the theoretical framework of real options have confirmed that it is optimal for a firm to postpone the investment under the assumption of uncertainty and irreversibility. The investment threshold derived under these assumptions will be higher than the break-even point in the analysis of net present value (NPV) when the market uncertainty and the firm's operational flexibility are assumed away. Therefore, if the host country wants the investment to be made earlier than the firm would like to make it, the host country must compensate the firm, usually in the form of a subsidy package. While a firm holds the option to make an investment at its optimal timing, a host country also holds the option to offer a subsidy package. To decide when to offer the subsidy package, the host country needs to make a trade-off between the incremental welfare benefits and tax revenues from an earlier investment and the cost of the subsidy package consisting of tax relief and investment support. The option to offer a subsidy package held by a host country is similar to the option to make an investment held by a firm in the way that both the country and the firm have to make trade-offs between the relevant benefits and costs.

Since the incentives used to attract FDI can take various forms, the concern about which one is better and how the 'optimal' subsidy package should be formed is quite universal. Yu *et al.* (2007) reached the conclusion that investment support is better than tax relief, suggesting that only the investment support should be used by the host country to attract FDI. However, in practice, most countries use a combination of investment support and tax relief. To reconcile the practice with the theory, this thesis presents the argument that it is the value rather than the form of the subsidy package that matters. When a host country is inclined to promote FDI and expects the investment to be made at its desired timing, the only thing that matters is the value of the optimal subsidy package. 'Optimality' suggests

that the subsidy package should be adequate, neither too much nor too little. Given the value of the subsidy package, the specific ways in which the investment support and tax relief are combined do not really matter and can take various forms. The combination of investment support and tax relief only matters in the sense that the total value of the subsidy package must be 'optimal'.

The real options model we have discussed so far is the 'standard' real options model, which applies to the case of a foreign monopolist investing in a single host country. We also take advantage of the real options game model to account for the effects of preemption risk. The real options game model incorporates the theoretical concepts of game theory since many industries are characterised not only by uncertainty but also by strategic interactions among market participants. In the second chapter of this thesis, we analyse two situations 1) when firms are competing to invest in a host country and the winning firm will preempt other firms' investments and 2) when countries are competing to attract an investment to their own locations and the winning country will preempt other countries.

When a firm decides to invest and take part in the business activities in a foreign country, it can choose among many different entry modes. The second set of research questions analysed in this thesis relate to market entry modes. We look at the optimal timing and value of an investment subsidy given different entry modes and investigate the optimal mode of entry for a subsidy. Entry mode has been defined by Sharma and Erramilli as follows: A structural agreement that allows a firm to implement its product market strategy in a host country either by carrying out only the market operations (i.e. via export modes), or both production and marketing operations there by itself or in partnership with others (contractual modes, joint venture, wholly owned operations).(2004, p. 2)

According to Peng, 'these models differ significantly in terms of cost, commitment, risk,

return, and control' (2002, p. 336) and can be categorised into two major types: non-equity and equity modes. The former includes export and contractual modes, which reflect relatively smaller commitments to overseas markets. The latter includes joint ventures (JVs) and wholly-owned subsidiaries (WOSs), which indicate relatively larger commitments to overseas markets.

Entry mode research is also one of the most researched areas by scholars, market practitioners, and policy makers. Research on entry modes may involve identifying the factors that may affect the firms' choices of entry modes, evaluating the firms' post-entry performances and explaining how the choices of entry modes affect the firms' post-entry performances. Many theories and constructs have been proposed in entry mode research. Some of them have been long-established and frequently applied, such as the transaction-cost theory, internalisation theory, and culture/cultural distance theory. Some theories and constructs are relatively new but also provide important insight into this area, such as the institutional theory, organisational theory, and uncertainty theory. In this thesis, we take into account the factor of uncertainty and focus on two types of equity modes: a JV and a WOS. We employ real options valuation techniques to evaluate the investment projects when different entry modes are adopted. We derive their respective investment thresholds and analyse the effect of different entry modes on the timing of investment. We investigate whether one mode seems to be more favourable than the other under certain circumstances. We also investigate when, how, and how much the host country should subsidise the firm in order to induce an early arrival of investment when the firm can choose between the two types of entry modes.

In the above analysis, we do not take into account product market competition. We usually treat the payoff of the investment project or the output price as a state variable that



follows a certain process, in particular the geometric Brownian motion with no restrictions. Thus, the state variable can range over  $(0, \infty)$ . However, in practice, there are always restrictions on the state variable. In a competitive industry, the firms' free entry to and exit from a competitive market will result in both the upper and lower bounds of the state variable. Our final set of research questions relate to the effect of product market competition. In the last chapter of this thesis, we study investment timing and choice of entry mode when the state variable is subject to a doubly absorbing barrier process. We attempt to address the following questions: When is the market competitive? How do the entry and exit of firms affect the valuation of the investment projects and investment thresholds? What are the effects of product market competition on the value of the investment projects and timing of the investment when different entry modes are adopted? How should the host country subsidise the firms to speed up the investment under this market structure? We also try to investigate whether one entry mode will be preferred under this market structure.

## 1.2 Contributions

Corresponding to the research questions raised above, the contributions of this thesis are three-fold. First, we derive the optimal form and timing of a subsidy package as well as the characteristics of the industries that are targeted for subsidies. Second, we show that investment subsidy can affect the choice of entry modes. Third, we demonstrate the effects on investment subsidy when there is competition in the product market. The following points summarise these contributions in more detail.

With respect to the optimal form and timing of a subsidy package (investigated in Chapter 2) the following conclusions can be drawn:

- The investment subsidy should always be structured in such a way that it provides a

kind of 'reward' for the speed-up of the investment and a 'penalty' for the delay. The optimal subsidy package should always compensate the firm for giving up the delay of the investment opportunity (i.e., giving up the value of waiting) and making the investment immediately.

- When the investment subsidy is offered at a lower trigger point (i.e., is offered earlier), the ratio of the welfare benefits to the amortised investment cost is higher.
- The preemption risk in the market for investment (i.e., a situation in which the investment has a positive externality for the host country but a negative externality for the firm's competitors) will lower the trigger point for the optimal investment subsidy.
- The preemption risk in the market for subsidy (i.e., a situation in which the investment has a positive externality for the host country but a negative externality for the country's competitors in the market for subsidy) will lower the trigger point for the optimal investment subsidy.

With respect to the relationship between investment subsidy and the modes of entry (investigated in Chapter 3), we study the modes of entry as a JV between the firm and the host country, where the host country retains the right to maintain output at maximum capacity in future states, versus the mode of entry as a WOS, where the firm retains all operational flexibility with regard to output. The following conclusions can be drawn:

- For modes of entry that have the same investment trigger in an unsubsidised world (i.e., would happen at the same point in time) and no subsidy is offered, the firm prefers the WOS as the optimal mode of entry but the host country prefers the operationally less flexible JV.

- For modes of entry that have the same NPV at the point of investment in an unsubsidised world, but the timing of investment is different and no subsidy is offered, the firm prefers the WOS. The preference of the host country depends on the parameters.
- For subsidised entry, when the investment triggers are identical in an unsubsidised world, the host country obtains the maximum welfare by offering a subsidy for a WOS as the mode of entry. This also holds when the NPV at the point of investment in an unsubsidised world are the same regardless of mode of entry.
- For a JV to be the preferred mode of entry when an investment subsidy is offered, it must have some distinctive welfare benefits that are not associated with a WOS, for instance knowledge transfer benefits.

With respect to the effects of product market competition on investment timing and choice of entry mode (investigated in Chapter 4), the following conclusions can be drawn:

- The cost structure of the investment is given endogenously by the constraint that both modes of entry must be competitive in an unsubsidised world (i.e., both have the same entry trigger point to the industry where the NPV is zero, and both have the same exit trigger point from the industry where the NPV of the future operation is zero). Therefore, there is no need to normalise the investment trigger points or the NPVs of the investment.
- The conclusions obtained in Chapter 3 still hold. Competition will not affect the problem of choosing the optimal mode of entry, and unless a JV has some distinctive welfare benefits that cannot be associated with a WOS, the optimal mode of entry is a WOS.

## 1.3 Existing Literature

The analyses in this thesis relate to several strands of literature. The research objects of this thesis are investment decisions about timing and entry modes, FDI incentives, and the effects of market structure on them. The existing literature related to these objects will be reviewed and summarised in this section. The literature related to the methodology adopted in this thesis – the standard real options model and the real options game model is also reviewed.

### 1.3.1 Investment Timing

The investment timing decision is one of the central concerns of decision makers within a firm. This thesis focuses on the FDI timing problem and investigates how a host country can affect it using investment incentives.

Although it can be traced back to Vernon (1966) who proposed the ‘Product Cycle Hypothesis’, which offers a cost-based rationale for the switch from exporting to market-seeking FDI and then to cost-orientated FDI, the first attempt to predict the timing of the switch was made by Aliber (1970). However, the early analysis of FDI timing either took it as exogenously given or analysed it in a deterministic model (Buckley and Casson, 1981; Mackie-Mason, 1990). Rivoli and Salorio (1996) pointed out that the existing literature offers rich explanations of the ‘why’, ‘where’, and ‘who’ of FDI, but there are few studies on the timing or the ‘when’ of FDI (e.g., Buckley and Casson, 1981; Casson, 1994). The early analyses also ignored two important features of the investment: uncertainty and irreversibility. These two features have been shown to profoundly affect the investment decisions. ‘It also undermines the theoretical foundation of standard neoclassical investment models, and invalidates the net present value rule’ (Pindyck, 1991), which has been widely used in capital budgeting and

investment decision making and suggests firms commit to the projects with positive NPVs.

Intuitively, when the market outlook is uncertain and the investment expenditures are hard to recover, it is rational to be cautious and to wait and see how the market evolves. Holding the opportunity to invest in a project with future payoffs is analogous to having a call option on a common stock paying dividend, and making the investment is like exercising the call option. This flexibility in investment timing actually has value. McDonald and Siegel (1985) introduced uncertainty and identified the effect of the shut-down option on the initial investment decision. They argued that, when investment environment is highly uncertain in the sense that the future revenues from an investment project or the costs to install the investment are uncertain, there may be an option for the firm to shut down the business if operating revenues are less than variable costs. This shut-down option will affect the initial investment decision. They applied option-pricing techniques to the investment problem when a firm has the shut-down option. McDonald and Siegel (1986) studied the optimal timing of investment when the investment project is irreversible and the investment environment is uncertain. The benefits and the costs associated with the investment are assumed to follow continuous-time stochastic processes, in particular the geometric Brownian motion. They identified the value of the option to invest and derived the optimal investment rule – that it is optimal to wait until that the benefits from the project are sufficiently large compared with the investment costs. Pindyck (1991) stressed two important characteristics of most investment expenditures. First, most of the investment expenditures are irreversible in the sense that they are sunk costs and cannot be recovered. Second, the firms can choose to wait before it makes investment expenditures. He derived the optimal investment rules using option-pricing methods and dynamic programming. Pennings (2000) argued that it is possible to influence the timing of overseas investment by a zero cost package

consisting of a front-loaded lump sum financed by a back-loaded tax on profits. Pennings (2005) showed that the cheapest subsidy package to attract new investment is to provide a front-loaded investment combined with a positive corporate tax rate on back-loaded profits. Yu, Chang, and Fan (2007) showed that if the host country can choose between providing cheap land and tax subsidy, it is better off with a front-loaded support in the form of cheap land, while Danielova and Sarkar (2011) pointed out that, when debt financing is available, the investment support may not dominate tax relief as the cheapest way to attract new investment since tax cuts will also reduce the value of the tax shield and, as the firm may default at some point in the future, the equity horizon may be truncated. Under the assumptions that the discount rates for the government and the private firms are different and that the government has to borrow money to finance the investment subsidy, Sarkar (2012) provided an alternative explanation for the country to provide the investment subsidy and tax the profits at the same time.<sup>2</sup>

### 1.3.2 Entry Modes

Choice of market entry mode is considered a critical strategic decision (Lu, 2002). We also study a firm's choice of entry mode and compare the modes of entry as a JV and a WOS under different situations.

Foreign-market entry modes can take various forms and can be grouped into two major types: non-equity and equity modes. The former type includes exporting, licensing, franchising, and subcontracting, and the latter includes JVs, WOSs, greenfield investments, brownfield investments, mergers and acquisitions, etc. The enormous growth in FDI is often accompanied by a significant increase in the number of multinational enterprises (MNEs).

---

<sup>2</sup>In Chapter 2, we prove that the front- or back-loaded subsidies make no difference to the country's option. In other words, the form of investment subsidy does not matter.

As mentioned above, entry mode research is one of the most researched areas. Werner (2002) suggested that entry mode research is the third most researched field in international management, just behind FDI and internationalisation. Werner pointed out that entry mode research includes 'the predictors of choices of entry mode, predictors of international equity ownership levels, and consequences of entry mode decisions' (2002, p. 281). Meyer *et al.* (2009) showed how alternative modes of entry allow firms to overcome different kinds of market inefficiencies related to both characteristics of the resources and to the institutional context in emerging economies.

The recent review article of Canabal and White III (2008) examined the empirical studies published during the time period from 1980 to 2006. From that paper, we can easily find the most commonly used theories in entry mode research and the factors that will affect the firms' choices of entry modes. Among the theories that have been proposed, some have been long-established and often applied. New theories and constructs have also emerged. For example, the transaction-cost theory is the most important and widely used theory. The basic rationale behind this theory is that firms always seek to minimise their costs of entering and operating in a foreign country (Hennart, 1989; Williamson, 1979, 1985). The second most commonly used theory is the OLI theory where OLI stands for ownership, location, and internalisation. This theory is also referred to as the 'eclectic paradigm' (Dunning, 1993). The third most commonly applied construct is the culture or cultural distance theory (Hallén and Wiedersheim-Paul, 1979). The relatively new theories include the institutional theory, organisational capacities, and uncertainty. Institutional theory suggests that, when a firm enter a new market, it must operate in the context of certain rules, norms, and values (Davis, Desai, and Francis, 2000; Meyer and Nguyen, 2005). The embedded isomorphic pressures can have a significant influence on the firm's choice of entry mode. Organisational capabil-

ities theory investigates a firm's capabilities related to the choice of entry mode (Erramilli, Agarwal, and Dev, 2002; Chen and Hennart, 2002). 'Uncertainty' was defined as 'unpredictability of environmental or organizational variables that have an impact on corporate performance' by Miller (1993, p. 694). It also has an effect on the firm's entry mode strategies (Brouthers, Brouthers, and Werner, 2000, 2002; Erramilli and D'Souza, 1993). Other theories and constructs include control, internationalisation, risk, resource-based view, FDI, knowledge-based view, etc. In summary, it appears that early theories are often based on economics (e.g., transaction-cost theory, internalisation, etc.) and psychology (e.g., culture or cultural distance), while theories from different fields in recent studies have been applied and integrated to provide a better understanding of the practice of entry mode selection.

In the existing studies, the most commonly used statistical methods are logistic regression and multinomial logit. Other methods include discriminant analysis, probit, multiple regression, and exponential estimation. Within these regressions, the most commonly used dependent variable is a dichotomous variable, such as WOS versus JV, export versus FDI, etc. The equity level is also commonly used as a dependent variable. It is not surprising that the number of factors used as independent variables is very large since there are so many theories and constructs to account for the choice of entry mode. In general, most studies focus on the influences of the factors on the choice of entry modes.

Canabal and White III (2008) suggested future empirical researchers use different entry modes as independent variables to study the effects of choice of entry mode on the post-entry performances of the firm. We study the issue theoretically under the framework of the real option theory to study the timing of investment, and we can also apply this theory to analyse the choice of entry modes. For example, JVs are often considered a means to deal with market uncertainty since they have the options to acquire or disinvest according to



market conditions. Therefore, JVs can be analysed under the theoretical framework of real options. In this thesis, we focus on the effects of the firm's choice between a JV and WOS on the timing and value of the investment. Existing literature in this specific area is quite limited.

Dixit (1989) and Kogut (1991) introduced market uncertainty (e.g., unstable revenue, changing product price and investment cost, evolving technology, etc.) to the problem of foreign-market entry decisions. Dixit (1989) focused on the timing of investment (entry). Following their method, Rivoli and Salorio (1996) discussed the strategic perspectives on the timing of investment. Kogut (1991) considered a JV an option to acquire or expand. Chi (2000) analysed the acquisition and disinvestment of JVs as real options. Chi and McGuire (1996) discussed the strategic perspective on the choice of market entry modes. However, until Pennings and Sleuwaegen (2004), there were no theoretical models that successfully integrated the analysis of investment timing and choice of entry mode simultaneously. Pennings and Sleuwaegen (2004) argued that investment timing and choice of entry mode can be considered at the same time and derived the decision rules for when to switch from exporting to establishing a JV or WOS under differential taxation. Since the choice of entry modes can affect the value of the investment project and the investment threshold, the firm will always choose the optimal mode of entry. If the firm can choose among different entry modes, this kind of flexibility is valuable and must be taken into account when we evaluate the investment project.

### **1.3.3 Real Options**

As mentioned above, when investors have the option to defer the investment under uncertainty and irreversibility, real options theory should be used in decision making. In this

thesis, we employ the standard real options model in the case of a foreign monopolist investing in a single host country. When the strategic interactions among market participants are taken into account, we take advantage of the real options game model to account for the effects of preemption risk.

The concept of 'real options' was first introduced by Myers (1977). He pointed out the similarities between future investment/growth opportunities and financial options, and considered the value of real options to be the value of the investment/growth opportunities in present value terms. In other words, the value of real options can be viewed as the present value of the right to buy real assets when market conditions are favourable in the future. This claim can be viewed as a call option on real assets. Ross (1978) identified the inherent potential investment opportunities. He regarded such investment opportunities as real options and discussed the theories of real options valuation. Pindyck (1991) also stated that an irreversible investment opportunity is like a financial call option that gives the holder the right, not the obligation, to pay an exercise price and receive an asset, at some future time, when the market conditions are favourable. Luehrman (1998) compared the real options with call options and drew a clear picture of the similarities between real options and financial options.

Like a call option, the option to invest (i.e., the real option) is valuable when the future payoff of the investment is uncertain. If the market condition improves, the firm can make the investment and the payoff of the investment will increase. If the market condition deteriorates, the firm does not have to engage in investment, and all its loss is the value of the investment opportunity. The real options help the firm retain the potential for future profits and avoid the possible losses. Therefore, the real options are valuable. This finding undermines the theoretical foundations of the traditional NPV approach in decision mak-

ing. When the NPV rule is applied, the management flexibility is actually assumed away, and the real options attached to the investment are ignored. Myers (1984) determined the shortcomings of the discounted cash flow (DCF) analysis. Taking into account real options, he recommended that investment decisions should be based on option pricing rather than the DCF approach. Hodder and Riggs (1985) argued that the risks of investment projects gradually decrease and that management flexibility may also reduce the risks. Thus, using a single discount rate throughout the valuation of the project may not be appropriate. Trigeorgis and Manson (1987) pointed out that the traditional NPV or DCF approach implicitly assumes away the future uncertainty and ignores the management flexibility. Thus, the NPV or DCF rule may result in a biased result in decision making. Similar opinions are also held by Brealey and Myers (1992), Dixit and Pindyck (1995), Ross (1995), and others. Thus, the inherent options of an investment and the management flexibility can add value to the investment and must be taken into account when investors make investment decisions.

Real options can be classified into several categories. Trigeorgis (1993, 1996) categorised real options into seven types: option to defer, staged investment option, option to alter operating scale, option to abandon, option to switch, growth option, and interacting option. Dixit and Pindyck (1994) divided the real options into five categories: option to defer, option to exit, lay-up option, scrapping option, and incremental option. Amram and Kulatilaka (1999) grouped real options into five types: option to defer, growth option, flexible option, option to exit, and learning option.

In summary, when the investment environment is uncertain and the investment expenditure is irreversible, it is better to use the real option theory for decision making. In this thesis, we follow the basic model of Dixit and Pindyck (1994) in the hope to gain insight on the value of management optionality, investment timing, and subsidies.

The real option approach can be applied to a wide variety of situations. Lander and Pinches summarised the application areas and topics, such as: Natural resources, competition and corporate strategies, manufacturing, real estate, international, research & development, regulated firms and utilities, mergers, acquisitions and corporate governance, interest rates, inventory, the labor force, venture capital, advertising, law, ‘hysteretic’ effects and firm behavior, and environmental compliance and conservation. (1998, p. 540)

In addition, the conceptual framework of real options has also been applied to explain social activities, such as marriage, suicide, legal reform, and constitutions (Dixit and Pindyck, 1994; Ch. 1). Using the real option approach, Wang *et al.* (2010) derived a pricing model for football player transfer and analysed the effects of injuries on the value.

## **Real Options Valuation**

The valuation methods of real options can be categorised according to the continuity of variables or the methods adopted for pricing the real options.

According to the continuity of the variables, the valuation models can be divided into a discrete-time model and continuous-time model. Binomial methods are the most applied discrete-time models to value different types of real options. Given that most real options are analogous to American style options, this method is flexible enough for the decisions to be made at each node. However, it should be noted that the binomial method has difficulty handling high-dimensional problems. When the continuous-time model is employed, time is considered to be continuous and infinite, and the variables are always assumed to follow certain processes, for instance the geometric Brownian motion. McDonald and Siegel (1986) assumed both the payoff and the cost of the investment follow a geometric Brownian motion and derived the value of the option to defer. Carr (1988) derived a valuation formula for a compound exchange option by assuming that the returns on the underlying assets follow a

geometric Brownian motion.

There are three major methods to value real options. The contingent claims approach applies option-pricing theory to the valuation of real options. It regards real options as contingent claims whose values depend on the values of other assets. By forming a riskless portfolio consisting of real options and other assets, the value of real options can be calculated. The dynamic programming approach is also employed to value real options. Both the contingent claims approach and the dynamic programming approach are used extensively in the work by Dixit and Pindyck (1994). The Monte Carlo simulation method has also been increasingly applied to real options valuation, especially to high-dimensional problems. Boyle (1977) is one example of this. Gamba (2002) used the Monte Carlo simulation method to value multiple real options. Recent developments in real options valuation include the Datar-Mathews method (Mathews, Datar, and Johnson, 2007) and the fuzzy payoff method (Collan, Fullér, and Mezei, 2009).

### **Standard Real Options Models**

The standard real options models are used extensively in real options literature (see e.g., Brennan and Schwartz, 1985; McDonald and Siegel, 1986). As summarised by Dixit and Pindyck (1994), the focus of the standard real options model is the derivation of the firms' value functions and the investment thresholds under the assumption of risk-neutrality of the firms and the absence of arbitrage opportunities. The assumptions imply that the sum of the flow payoff and the expected capital gain over an infinitesimal time interval must equal the risk-free return of the capital over the same time interval. Once the investment threshold has been derived, the principle of the use of the investment threshold is that a firm should invest at the instant when the investment threshold is crossed for the first time.

## Real Options Game Models

Real options theory is employed in making investment decisions when the market conditions are highly uncertain. However, the market conditions are characterised not only by uncertainty but also by strategic interactions among market participants. This promotes the real options models to incorporate the concepts of game theory. However, the standard real options approach does not take into account the effect of competition. When only one firm is to invest in an uncertain world, real options theory suggests that it is better for the firm to wait and see. The firm is actually a monopolist. However, in a competitive market, when firms make investment decisions and take certain actions, they must take into account how their competitors will think and react. This can be viewed as a 'game' among firms.

Smets (1993) first incorporated interactions between firms into real option analysis. His methodology is followed by many researchers. Since then, a new stream of literature on the merger between the real options theory and game theory has emerged. Chevalier-Roignant *et al.* (2011) suggested the real options game models can be used to analyse various research objects, such as the timing of entry, the staging of entry, the scale of production, the type and quality of product, etc.

According to the continuity of the variables, the real options game models can be categorised into discrete-time models and continuous-time models.

Smit and Ankum (1993) analysed the situation when both firms have the opportunities to enter a new market with the same costs. They incorporate binomial models to describe the movement of the market and the decisions of the two firms. They assume that the firm who enters the market first will have the higher market share, and if they enter the market at the same time, they will have the same market share. The information is assumed to be complete. Then, the two firms need to decide whether to enter the market simultaneously

or sequentially under different situations. Zhu and Weyant (2003a, 2003b) analysed the interactions between two firms using the binomial method by assuming that only one firm has complete information while the other firm just knows the probability distribution of the cost of its rival.

Dixit and Pindyck (1994) proposed a continuous-time, symmetric duopoly model based on Smets (1991). They assumed that the product price is affected by some random variable  $Y$ . When  $Y$  is smaller than some threshold  $Y_1$ , neither firm will invest; when  $Y_1 < Y < Y_2$ , only one firm will invest, and when  $Y > Y_2$ , both firms will invest. However, their model does not take into account the first-mover advantage. Weeds (2002) analysed competition in research activities in an oligopoly model and investigated the effects brought by the competition pressure on the firm's research activities. She followed the methodology of Dixit and Pindyck (1994) and considered the first-mover advantage, especially the winner-takes-all situation. Mason and Weeds (2010) considered the positive and negative externalities of the leader to the follower. They suggested that the characteristics of externalities will affect the investment decisions.

According to the type of information assumed in the models, the real options game models can be grouped into models with complete information and models with incomplete information. Most models we have mentioned above assume complete information, except Zhu and Weyant (2003a, 2003b), which are the examples of discrete-time models with incomplete information. Lambrecht and Perraudin (2003) derived a dynamic model with incomplete information. Their model also takes into account competition in the form of preemption. The assumption of incomplete information implies that firms do not know exactly the costs of its competitors but only know the probability distributions of the costs. The effects of preemption and incomplete information on the investment threshold are investigated in their

paper.

In this thesis, we extend the analysis of Lambrecht and Perraudin (2003) to the situations in which the firms are competing to invest in a single host country and in which the countries are competing to attract the investment of a firm to their own locations.

Other literature employing real options game models include the analyses of investing in a new project (see e.g., Grenadier, 1996; Huisman and Kort, 1999; Boyer *et al.*, 2004; Murto, 2004; Pawlina and Kort, 2006), exiting the industry (see e.g., Sparla, 2004; Murto, 2004), and staged investments (see e.g., Miltersen and Schwartz, 2004).

### 1.3.4 Investment Incentives

The FDI incentives have been extensively studied in the existing literature. Our analysis assumes that investment incentives can be used as means to affect a firm's investment decisions. The value of the subsidy package can be adjusted by a host country to provide a reward for speeding up the investment and a penalty for delaying the investment. In this section, we review the main theoretical and empirical studies of investment incentives.

In economics literature, it is generally agreed that FDIs are mainly attracted by strong economic fundamentals of the host countries, such as market size, real income levels, availability of skilled labour, availability of infrastructures and other facilitates, and political and macroeconomic stability (see Dunning, 1993; Globerman and Shapiro, 1999; Shapiro and Globerman, 2001).

Investment incentives are also widely used to attract FDI. However, empirical studies show that the effects of investment incentives are very limited in the determination of the international pattern of FDI (Blomström *et al.*, 2000). Investment incentives are considered to be secondary to the economic fundamentals in attracting FDI. They might only play a



role for investment decisions on the margin. In other words, investment incentives may alter the firms' investment decisions only when they face the choices that are more or less the same in economic fundamentals.

As mentioned above, investment incentives can be broadly categorised into two major types. Tax incentives, which are fiscal in nature, include tax holidays, special zones, investment tax credit, investment allowance, accelerated depreciation, reduced tax rate (typically the corporate income tax rate), exemptions from various taxes, and financing incentives (e.g., reduced withholding taxes on dividends) (Klemm, 2009)). Investment subsidies, which are financial in nature, include grants, infrastructure subsidies, investment financial subsidies, free land or land subsidies, and soft loan or loan guarantees. Other incentives include market preferences, monopoly rights, etc. Since financial subsidies usually come from the government budget directly, they are expected to be used more frequently by developed countries. Developing countries are more inclined to use fiscal incentives that do not require up-front use of government budget.

Investment incentives have been extensively studied, typically from the aspects of why they are granted, whether they can be justified, what their costs and benefits are, and how to choose the appropriate forms. However, the relative advantages and disadvantages of investment incentives in promoting FDI have never been clearly established. Some spectacular successes as well as notable failures are all documented.

Tax incentives are commonly employed in promoting FDI around the world and especially in developing countries. A more general economics literature has confirmed the significance of the effect of taxation on FDI (Hines, 1999; Devereux and Griffith, 2002; De Mooij and Ederveen, 2003). This finding implies that tax incentives may also affect FDI. Mintz (1990) found that a tax holiday is used in about half of developing countries. Some studies observed

that indirect tax incentives, such as investment tax credit and accelerated depreciation, are more popular in developed countries (Cummins, Hassett, and Hubbard, 1996; Zee, Stotsky, and Ley, 2002). Morisset and Pirnia (2000) found that the investment subsidies are used more often than tax cuts in Western-European countries. Bloom *et al.* (2002) paid special attention to R&D incentives (e.g., tax credits). Klemm and Van Parys (2009) found that tax incentives, especially tax holidays, can boost FDI but have no robust effect on total investment.

Despite their popularity, economists are actually sceptical of tax incentives. To justify tax incentives on theoretical grounds, their costs and benefits must be assessed. Descriptions of tax incentives and their costs and benefits can be found in the work of Bird (2000), Shah (2005), Zee, Stotsky, and Ley (2002), and Klemm (2009). Some empirical studies show that the overall benefits of tax incentives are unclear. Sometimes they may work in promoting FDI when certain preconditions are met and the correct design is chosen. Detailed assessments of almost all typical tax incentives are provided by Klemm (2009). The decision of whether to offer tax incentives and the choice among different types of tax incentives should be based on the evaluation of their respective costs and benefits. It should be noted that the total costs of tax incentives are beyond the loss of tax revenues, and according to Klemm: They include distortions to the economy as a result of preferential treatment of investment qualifying for incentives, administrative costs from running and preventing fraudulent use of incentives schemes, and social costs of rent-seeking behaviour, including possibly an increase in corruption. (2009, p. 11)

Therefore, it is difficult to quantify the actual costs of tax incentives. In addition, the benefits of tax incentives are also difficult to quantify since the economic performance can be affected by many other factors. It is suggested that when we evaluate the benefits of

tax incentives, the aggregate investment must be evaluated since other investments may be crowded out. The cost-benefit analysis of tax incentives may be misleading if they ignore the general equilibrium effects.

The effects of investment subsidies seem to be more straightforward. They reduce the initial costs to set up an investment. The question left is whether these costs can be covered by the benefits from the investment (from the host country's perspective). In practice, the two types of investment incentives are often used together (Bond and Samuelson, 1986; Nam and Radulescu, 2004; Pennings, 2000, 2005; Yu *et al.*, 2007).

Among existing studies concerning investment incentives, some of them have paid attention to the situations in which uncertainty exists. MacKie-Mason (1990) analysed nonlinear taxes and found that the tax policy may have surprising effects on investment decisions when the output is uncertain. Rodrik (1991) and Hassett and Metcalf (1999) studied the effect of taxes on investment when uncertainty exists in the tax system and tax rate. Pennings (2000, 2005) investigated why host countries subsidise the firms and tax away the benefits at the same time and reached the conclusion that by providing a self-financed subsidy package, the host country can lower the investment trigger and speed up the investment. Yu *et al.* (2007) argued that investment subsidies dominate tax cuts. By providing an investment incentive of the same value, investment subsidies will result in a lower investment threshold and an earlier arrival of the investment, and the costs of investment subsidies will be lower to obtain the same investment threshold. However, their conclusion contradicts the fact that both types of investment incentives are used by host countries. Danielova and Sarkar (2011) and Sarkar (2012) challenged the conclusion of Yu *et al.* (2007) and offered some explanations for the fact that both types of incentives are used together by introducing debt financing.

In this thesis, we will study the effects of investment incentives under uncertainty. It

should be stressed that the models actually study the effects on the margin, with all other things being equal. Through the cost-benefit analysis, we will try to discover the optimal subsidy package consisting of investment support and tax relief. We argue that neither the host country nor the firm should be able to extract rent from providing (by the host country) or receiving (by the firms) the subsidy packages. On one hand, the host country should know what the optimal subsidy package is. Otherwise, the host country may give up too much value to the firm (Morisset and Pirnia, 2000). On the other hand, the firm should also be aware of the value of the subsidy package to avoid losses. In our analysis, we regard the subsidy package to be 'optimal' when the incremental benefits from providing the subsidy package are maximised.

## 1.4 Overview of Remaining Chapters

In this chapter, we have reviewed the research questions, contributions, and existing literature. The rest of the thesis is organised as follows.

In Chapter 2, we introduce the standard real options model and derive the value of the investment project and investment threshold. By assuming that the host country can affect the firm's investment timing decision through adjusting the value of the subsidy package, we derive the optimal form of subsidy. We evaluate the host country's incremental welfare benefits and the costs of the subsidy package, and obtain the optimal timing to offer it. Then, we introduce the real options game model and examine the effect of competition in the form of preemption on the timing of investment and the value of subsidy package. Two situations are analysed when different firms compete to invest in a single country and when different countries compete to attract investments to their own locations.

In Chapter 3, we consider the timing of investment and the choice of entry modes simul-

taneously. We evaluate the investment projects and the associated welfare benefits when the firm can choose between two different entry modes – a JV and WOS. We study the effects of different entry modes on the timing of investment and compare them and find that, when there is no subsidy offered, the firm prefers a WOS, while the host country prefers a JV. Next, we analyse the situation in which the host country is able to influence the firm's investment timing decision and choice of entry mode using a subsidy package. We find that both the firm and the host country prefer a WOS in this situation. We find that a JV will be preferred only if it has some distinctive welfare benefits that are not associated with a WOS, for instance knowledge transfer benefits.

In Chapter 4, we study the effect of competition in the product market on investment timing and choice of market entry mode. When the movement of output price is regulated, we evaluate the investment projects and the welfare benefits by solving systems of equations. We find that the cost structure of the investment is determined endogenously by the constraint that both modes of entry must be competitive in an unsubsidised world. Firms in either mode will have the same entry trigger point to the industry and the same exit trigger point from the industry. We also find that the conclusion obtained in Chapter 3 still holds. In other words, competition will not affect the choice of entry modes – the optimal mode of entry is a WOS, unless a JV has some distinctive welfare benefits that cannot be provided by a WOS. In Chapter 5, we conclude the thesis.

# Chapter 2

## Investment Subsidy

### 2.1 Introduction

In this chapter, we study the decision by a country to influence investment behaviour of firms by offering investment subsidies. The objective of the country is to capture the incremental welfare effect of attracting an investment at an earlier time than would happen without the subsidy. Specifically, we look at the following questions:

- How should an investment subsidy be implemented to give the maximum effect?
- What is the optimal timing of the subsidies?
- How does the level of competition in the market for investment affect the optimal subsidy?
- How does the level of competition in the market for subsidy affect the optimal subsidy?

The analysis is applied to the area of FDI subsidy but has considerable relevance beyond this specific area, as it applies to any situation in which a country has an interest in influencing the investment behaviour of its firms. Investments that have externalities – this can be positive

externalities in the form of employment or knowledge transfers or negative externalities in the form of pollution – are relevant to our analysis. For instance, our model can be applied to the design of investment subsidy for firms that consider the investment in a switch from traditional to green technology. The objective for the country may be to meet welfare enhancing emission targets, and they may consider the use of investment subsidy to achieve this. Many of the recommendations for the design of such schemes that apply to FDI can be transferred directly into the problem of designing schemes for investments in green technologies.

The area of FDI is nonetheless one where there is both a long-standing practice of using incentives and a large related literature, and we discuss the empirical relevance of our findings by reviewing some of the evidence and casual observations in this literature. The number and size of the deals subsidising FDI are large. Thomas (2007) estimated that within the European Union in 2005 €8.4bn were distributed in regional aid, which probably underestimates the total number, and he cited estimates of between \$40-50bn for the US for 2002. An estimate by the World Trade Organization was a total of \$250bn in 2003 for 21 developed countries. The research questions above are therefore interesting in their own right, as it is important to understand how these deals are structured to give the maximum welfare effect in the cheapest way, which is the primary motivation of this chapter. The existing literature can only partially shed light on the questions we raise above, which forms another motivation.

Empirically, subsidy packages take many forms – cash grants or capital injections, tax relief, cheap loans or loan guarantees, guaranteed excessive rates of profits, below-cost supplies of inputs including land and power, to mention some – but we can essentially discuss only two classes of subsidy, those that provide a front-loaded investment support and those that

provide a back-loaded tax relief. Thomas (2007) found significant variation in all regions of the world. Some examples taken from his report are the following. In North America, the US often uses front-loaded incentives, such as accelerated depreciation, whereas Mexico uses exceptions from corporate income tax. In Central and South America investment incentives are common throughout the region, but Brazil heavily uses tax credits and tax exemptions. In Africa, Egypt makes use of tax holidays, whereas Morocco uses grants, tax credits, and tax holidays. In Europe, Ireland operates with low tax rates, whereas the UK makes use of grants. In the Asia-Pacific region, Australia makes use of grants, whereas Malaysia makes use of a combination of tax holidays and will allow depreciation of the investment in building and equipment at over 100% of the cost. When it comes to the timing question, there is very little related work done theoretically and empirically; the former due to the lack of dynamic modelling in this area. There is vast theoretical literature on the effects of competition in the markets for FDI investments and subsidy; however, there is little done in dynamic models with some notable exceptions (Pennings, 2000, 2005; Yu, Chang, and Fan, 2007; Asano, 2010, among others).

Our main findings are as follows. Form matters for investment subsidy. The optimal form of the subsidy package must provide some discouragement for the firm to defer the investment decision (i.e., the optimal subsidy should become smaller the longer the firm holds out before making the investment decision). We do not find, however, that implementation of the optimal form of subsidy matters beyond providing the necessary penalty for deferral. For instance, a dollar generated through a tax relief has the same effect as a dollar offered as cheap financing. We find, therefore, that the observed diversity of subsidy design is consistent with our model as long as the subsidy is calibrated to become smaller as the firm gets closer to the unsubsidised investment trigger. This effect is similar to the well-



known sales technique where special offers are valid only for a short period – implying it is withdrawn if we do not take advantage of it quickly.

The timing of subsidy depends on the ratio of welfare benefits to the amortised investment cost. Barring the effects created by first-mover advantages, this is the only determinant of the timing of investment subsidy. This implies that sectors where the ratio is high are likely targets for investment subsidy. The investment may bring new corporate capital and employment to an area that may be lacking in both, and it may also bring new technology to areas where technology has been lacking. These create welfare benefits that can justify investment subsidies. Surprisingly, even India, where the wage level is low, has used subsidies to attract labour-intensive FDI to areas where the unemployment is high and the investment cost is low (often in the form of call centres).

Competition matters, however, and more competition will generally lead to an increased activity in the investment subsidy market. We study competition in the market for investment in the form of preemption risk. If there is a first-mover advantage in the market for investment where the establishment of a facility by one firm has a deterring effect of the attractiveness of other firms to make similar investments, a competitive effect is generated for that investment. An example of such a first-mover advantage is strategic commitment. Consider, for instance, Phillips' large investment in compact disc (CD) technology in the early 1980s, which was made to deter its competitors from making similar investments. From a narrower perspective, Phillips would have benefited from delaying investment and gaining more information about whether the new technology would become a new standard in the music industry, but since the investment had a strategic commitment value, it chose to move early. Preemption risk leads, therefore, to rent dissipation. We find that the effect of an increase in preemption risk in the market for investment is that the investment is made

sooner at a lower commercial value, and a country seeking to attract FDI can utilise this effect to its advantage and offer subsidies for investments, which further speed up investment at even lower commercial value. The industries where preemption risk is high, therefore, are targets for investment subsidy.

We also study competition between countries. The effect here is similarly driven by preemption risk, where there is a first-mover advantage to the country offering investment subsidy that attracts new investment. A subsidy offered by one country leads to a loss of welfare in other countries where a similar subsidy is no longer feasible. This can also be interpreted as strategic commitment. For instance, a country may seek to attract investment in research and development facilities, which are very rare. Such investments are likely to strengthen the country's technological knowledge base and therefore have high welfare effects, but the scarcity of such investments generate competition between countries for such investments. Preemption risk between countries increases; therefore, the likelihood of investment subsidies being offered and the industries where such investments take place are also targets for subsidies.

These effects arise in the context of optimal timing decisions, developed to solve investment problems under uncertainty when the timing is part of the decision problem. These problems are discussed extensively in Dixit (1993), and our model uses the smooth-pasting techniques developed there. The timing problem is solved by working out the value of investment at any point in time, and comparing it to the value of the option to defer the investment. At the optimal point, both the values and the marginal value of both decisions are the same. If the first of these conditions is satisfied but not the latter, for instance if the marginal value of the investment is greater than the marginal value of the option to delay investment, then a deferral is expected to be profitable, although, at the time of investment,

the value of the investment and the option deferral are the same. This is inconsistent with value maximising behaviour; therefore, the only solution is that there is a smooth transition from the value of the investment option to the value of the investment itself.

The related literature consists of several strands. Some literature discusses aspects of subsidy design in dynamic models. Here, we find Pennings (2000, 2005), Yu, Chang, and Fan (2007), and Asano (2010), among others. A common theme in all of these researchers' models is that the decision to offer subsidy is an optimisation problem based on welfare for the host country, subject to offering a subsidy package such that the investment decision for the firm satisfies an optimal timing constraint for the firm. We argue that this problem does not take into account all of the firm's outside options. In particular, we argue that it must be the case that the combined value of the subsidy plus investment is at least as high as the value of the unsubsidised investment option. This constraint is violated in the research by Pennings (2000, 2005) and Asano (2010). Additionally, we argue that, at the optimal point, the firm should not be able to extract rent in excess of the value of its unsubsidised investment option. This constraint is not binding in the work by Yu, Chang, and Fan (2007).

There is also a strand of literature that discusses the welfare effects of FDI subsidy. Besley and Seabright (1999) provided an excellent overview of this literature. In addition to the immediate welfare effect of the FDI subsidy decision for the host country, they also examined the wider externalities on other non-subsidising countries. Black and Hoyt (1989) pointed out that subsidy may reduce distortions in the investment decision and therefore create welfare benefits. Albornoz *et al.* (2009) studied the effect of allowing acquisitions as an alternative to greenfield FDI. Chor (2009) studied FDI subsidy when small levels of subsidy have a selection effect by attracting only the most productive firms, and Fumagalli (2003) studied the welfare effects when investments in less developed regions have greater

welfare effects but lower profit potential than similar investments in more developed regions. The essential divide between the work cited above and ours is related to dynamics. We study the welfare effects of the option to change the timing of an investment project, which would ultimately be made in any case, with varying kinds of preemption risk in the market for investment and the market for subsidy. The one-shot models cited above do not capture this effect and will impose a winner-takes-all structure. For instance, in Chor's (2009) model, a selection effect is introduced that denies the losing firms in a subsidy game the opportunity to invest at a later stage. This will influence behaviour within the model, but in practice, the firm may anticipate multiple opportunities to make an investment further down the line, more in line with our dynamic model, which has less influence on behaviour.

There is a growing amount of literature on policy to encourage investments in green technology, but this literature is still relatively thin. Dutz and Sharma (2012) provided a comprehensive overview of the policy practice in this area, and Agliardi and Sereno (2012) built a model of the optimal switch from a non-renewable source of energy to a renewable source. However, Agliardi and Sereno (2012) did not analyse the effects of policy measures to influence the switching decision.

This chapter proceeds as follows. In Section 2, we present the model, and in Section 3, we present the main theoretical findings. In Section 4, we discuss the empirical implications of the model, and Section 5 concludes the chapter.

## 2.2 Framework

In this section, we set out the model, discussing the various aspects in separate subsections. First, we describe the investment opportunity for the firm, second, the investment subsidy, third, the timing of the investment subsidy, and finally, the competitive aspects linked to

preemption risk of various kinds.

### 2.2.1 Investment and Earnings

We outline a standard real options framework stripped down to its simplest form, where investments are equity financed. We suppose an investment  $I$  (net of all tax implications) at time  $s$  yields an earnings flow  $y_t$ , where  $s \leq t < \infty$ . The earnings are taxed at a corporate rate of  $\tau$ . The earnings flow  $y_t$  follows a geometric Brownian motion with risk-neutral drift  $\mu$  and diffusion  $\sigma$ , and we assume the firm can observe the earnings flow free of cost to make the investment at a time to maximise the NPV. The trigger value  $y^*$  is the solution to this problem, where the investment is made at the optimal stopping time that is defined as the event that the process  $y_t = y^*$  for the first time. The instantaneous risk-free rate is  $r$ .

The value of a claim on the earnings flow  $y_t$  by paying the investment cost  $I$ , at the investment trigger point  $y^*$ , can be written as:

$$V(y_t|t < \tau_1) = \mathbb{E} \left( \int_{\tau_1}^{\infty} e^{-r(s+\tau_1)} y_s (1 - \tau) ds - e^{-r\tau_1} I \right), \quad (2.1)$$

where  $\tau_1$  is the stopping time for the event that  $y_t = y^*$  for the first time. The value of a claim on the earnings flow  $y_t$  at the point the investment is just made is similarly:

$$V(y_t|t \geq \tau_1) = \mathbb{E} \left( \int_t^{\infty} e^{-r(s-\tau_1)} y_s (1 - \tau) ds \right). \quad (2.2)$$

Dixit (1993), for instance, showed that:

$$\mathbb{L}(V(y_t|t < \tau_1)) = 0, \quad \mathbb{L}(V(y_t|t \geq \tau_1)) + y_t(1 - \tau) = 0, \quad \mathbb{L} = \frac{1}{2} \sigma^2 y_t^2 \frac{d^2}{dy_t^2} + \mu y_t \frac{d}{dy_t} - r, \quad (2.3)$$

where  $\mathbb{L}$  is the infinitesimal operator associated with the Brownian motion governing the earnings process  $y_t$ . The solution to the first equation is  $V(y_t|t < \tau_1) = A_0 y_t^{\lambda_1} + B_0 y_t^{\lambda_2}$  where  $A_0$  and  $B_0$  are arbitrary constants, and  $\lambda_1$  and  $\lambda_2$  are the positive and negative roots, respectively, of the characteristic equation  $\frac{1}{2}\sigma^2\lambda(\lambda - 1) + \mu\lambda - r = 0$ . The roots are  $\lambda_1 = (\frac{1}{2} - \frac{\mu}{\sigma^2}) + \sqrt{(\frac{1}{2} - \frac{\mu}{\sigma^2})^2 + \frac{2r}{\sigma^2}}$  and  $\lambda_2 = (\frac{1}{2} - \frac{\mu}{\sigma^2}) - \sqrt{(\frac{1}{2} - \frac{\mu}{\sigma^2})^2 + \frac{2r}{\sigma^2}}$ . Note that  $\lambda_2 < 0 < 1 < \lambda_1$  for  $r > \mu$ . The solution to the second equation is  $V(y_t|t \geq \tau_1) = A_1 y_t^{\lambda_1} + B_1 y_t^{\lambda_2} + \frac{y_t(1-\tau)}{r-\mu}$ , where  $A_1$  and  $B_1$  are again arbitrary constants. Since the solution must satisfy  $V(ky_t|t \geq \tau_1) = kV(y_t|t \geq \tau_1)$ , however, the constants  $A_1$  and  $B_1$  must be zero. We impose boundary conditions or smooth-pasting conditions to identify the free parameters  $A_0$  and  $B_0$  in the expression for the value of the investment opportunity. Using value-matching and the smooth-pasting conditions, we find the optimal investment trigger point  $y^*$ , which is the solution of the problem of finding a smooth fit between the value of the investment opportunity  $V(y_t|t < \tau_1)$  and the value of the investment itself  $V(y_t|t = \tau_1) - I$ . In this case the investment trigger is given by:

$$y^* = \frac{I}{1-\tau}(r-\mu)\frac{\lambda_1}{\lambda_1-1}. \quad (2.4)$$

Note that given the assumptions of the model, the unsubsidised investment trigger point  $y^*$ , assuming there are no effects of competition, is exogenously determined.

### 2.2.2 Investment Subsidy

Suppose an unsubsidised investment will be made in a country at the investment trigger given by Eq. (2.4). Suppose a host country is willing to offer a subsidy package, denoted as  $K$ , which consists of a lump sum investment support  $\Delta$  and a tax relief  $\delta$ , which leads to earlier investment. We assume that both  $\Delta$  and  $\delta$  are functions of  $y_t$ , so that the value of the

subsidy package fluctuates with the earnings level  $y_t$ . If the firm makes the investment at time  $t$  when the earnings are equal to  $y_t$ , the firm receives  $\Delta(y_t)$  as an instant transfer at the time of investment, and will additionally keep  $y_s\delta(y_t)$  and  $s \geq t$  of its future earnings, which otherwise would be paid in taxes. The subsidy package is  $K(\Delta(y_t), \delta(y_t))$ . Let  $\tau_2$  denote the stopping time at which the subsidy is accepted and the investment is made. The value of the investment opportunity to a firm that accepts the subsidy is:

$$V(y_t|t < \tau_2, \text{Subsidy}) = \mathbb{E} \left( \int_{\tau_2}^{\infty} e^{-r(s+\tau_2)} y_s (1 - \tau) ds + e^{-r\tau_2} (K(y_{\tau_2}) - I) \right). \quad (2.5)$$

Note that, in this expression, we capture all value effects of the investment subsidy into the value function  $K$ . A natural constraint on the value of the subsidised investment opportunity is that it is at least as large as the value of the unsubsidised investment opportunity (i.e., that  $V(y_t|t < \tau_2, \text{Subsidy}) \geq V(y_t|t < \tau_1)$ ). It is not possible that the firm would accept an investment subsidy that would allow the country offering the subsidy to extract rent from the firm. On the other hand, we expect that the subsidy is no greater than it needs to be, so the constraint above is likely to be binding.

### 2.2.3 Timing of Subsidy

The host country receives welfare benefits from attracting the investment earlier than it would otherwise occur. The benefit takes the form of a constant flow  $w$  for the duration between the timing of the subsidised investment to the time the investment would have been made in any case. The stopping time for the event that the unsubsidised investment takes place is the event that  $y_t = y^*$  for the first time. If the country seeks to attract investment early, say at the stopping time for the event that  $y_t = y^{**} < y^*$  for the first time, the country receives a constant welfare benefit flow  $w$  from the latter stopping time to the

former stopping time (i.e., in the time it takes for the earnings flow to go from  $y^{**}$  to the first instance in which the earnings flow reaches  $y^*$ ). The cost of inducing early investment is  $K(\Delta(y^{**}), \delta(y^{**}))$ , and the country will set the optimal timing of its subsidy package to a time that maximises the welfare benefit of receiving the welfare flow  $w$  against the cost of inducing investment. If the country waits until  $y_t = y^*$  the net welfare effect is zero because the value of the benefit flow  $w$  is zero and because the cost of the subsidy package is also zero. If  $w$  is sufficiently large, it is always optimal to offer subsidy prior to this point in time. We can write the welfare benefit of the subsidy as follows:

$$W(y_t|t < \tau_2) = \mathbb{E} \left( \int_{\tau_2}^{\tau_1} e^{-r(s+\tau_2)} w ds - e^{-r\tau_2} K(y^{**}) \right), \quad (2.6)$$

where  $\tau_2$  is the stopping time for the event that  $y_t = y^{**}$  for the first time, and  $\tau_1$  is (as before) the stopping time for the event that  $y_t = y^*$  for the first time. After a subsidy package is offered and accepted at  $y_t = y^{**}$ , the welfare benefits take the value:

$$W(y_t|t \geq \tau_2) = \mathbb{E} \left( \int_t^{\tau_1} e^{-rs} w ds \right). \quad (2.7)$$

These expressions satisfy the following conditions:

$$\mathbb{L}(W(y_t|t < \tau_2)) = 0, \quad \mathbb{L}(W(y_t|t \geq \tau_2)) + w = 0, \quad (2.8)$$

where  $\mathbb{L}$  is defined above. The optimal timing of subsidy is the trigger point  $y^{**}$ , which maximises the welfare of the subsidy,  $W(y_t|t < \tau_2)$ .



### 2.2.4 Preemption Risk

Finally, we investigate the effect of preemption risk in the market for investment and in the market for subsidy. Let  $\tau_C$  be the stopping time at which the winner and losers of the race to make an investment first becomes known, and the investment is made by the winning firm. The value of the investment opportunity, conditional upon it belonging to the winning firm, is the following:

$$V(y_t|t < \tau_C, \text{Win}) = \mathbb{E} \left( \int_{\tau_C}^{\infty} e^{-r(s+\tau_C)} y_s ds + e^{-r\tau_C} (K(y_{\tau_C}) - I) \right), \quad (2.9)$$

and the value, conditional upon it belonging to the losing firm, is the following:

$$V(y_t|t < \tau_C, \text{Lose}) = 0, \quad (2.10)$$

where the right-hand side is zero because the winner who makes the investment destroys the value of the investment for the loser. Preemption risk of this kind was studied by Lambrecht and Perraudin (2003).

When there is preemption risk in the market for investment subsidy, the winning country receives the welfare benefit, but the loser will receive nothing. Again, using  $\tau_C$  as the stopping time at which the winning and losing countries become known and the subsidy is offered, we find that the welfare, conditional upon it belonging to the winning country, is the following:

$$W(y_t|t < \tau_C, \text{Win}) = \mathbb{E} \left( \int_{\tau_C}^{\tau_1} e^{-r(s+\tau_C)} w ds - e^{-r\tau_C} K(y^{**}) \right), \quad (2.11)$$

and the welfare, conditional upon it belonging to the losing country, is the following:

$$W(y_t|t < \tau_C, \text{Lose}) = 0. \quad (2.12)$$

The incremental welfare of the option to attract business by giving investment subsidy will, therefore, vanish completely unless there is some probability that the country can win the preemption game.

Note that the form of competition implied by preemption in the market for investment will have a rent dissipation effect in the sense that when the probability of winning the preemption game is low, the firm makes an investment that has a relatively low financial value since it is made earlier than would otherwise be the case. There is no effect on the product prices or the earnings flow to the winning firm. The case where competition has an effect on product prices is investigated in Chapter 4.

## 2.3 Theoretical Results

In this section, we review the theoretical results relating to the parts in the preceding section. First, we study the optimal design of the subsidy package, second, the timing of the subsidy, and finally, the effect of preemption risk.

### 2.3.1 Optimal Subsidy Design

A firm that owns an investment opportunity and is additionally offered a subsidy package will look at the investment decision as one where the timing of the investment maximises the value of the total investment plus subsidy package. The problem itself does not change, and we can apply the standard techniques developed by Dixit (1993). The firm, when deciding to make the investment at the stopping time at which the earnings flow reaches the investment/subsidy trigger point  $y^{**}$ , expects to make a present value of  $\frac{y^{**}(1-\tau)}{r-\mu}$  from its future earnings, spends  $I$  on making the investment, and accepts  $K(y^{**})$  in subsidy. The optimal stopping time for  $y^{**}$  is achieved when the value and the marginal value of the

total package equals the value and the marginal value of the option to defer the investment, respectively. We find the following results.

**Proposition 2.1:** *The optimal investment trigger for a firm faced with a subsidy package  $K(\Delta(y_t), \delta(y_t))$  is given by the investment trigger  $y^{**}$ , where:*

$$y^{**} = \left( y^* - \frac{K(y^{**})(r - \mu)}{(1 - \tau)} \frac{\lambda_1}{\lambda_1 - 1} \right) \left( 1 - \frac{r - \mu}{(1 - \tau)(\lambda_1 - 1)} \frac{d}{dy} K(y^{**}) \right)^{-1}, \quad (2.13)$$

where  $y^* = \frac{I}{1 - \tau}(r - \mu) \frac{\lambda_1}{\lambda_1 - 1}$  is the unsubsidised investment trigger.

We notice that the subsidy has a value effect in the sense that the investment trigger point is lowered by a positive value of  $K$ , which is measured by the first bracket on the right-hand side of Eq. (2.13). This effect is a straightforward compensation effect, in the sense that the firm now views the problem of timing from the point of view as the net investment cost  $I - K$ . There is, however, a secondary effect measured by the second term. We notice that it is not only the value of the subsidy that matters but also the marginal value. If the marginal value is zero, for instance, if  $K$  is represented by a lump sum in investment support that is not affected by the market conditions  $y_t$ , then  $\frac{d}{dy} K = 0$  and the second bracket equals one. In this case, the value effect of  $K$  is the only aspect that has an effect on the investment decision. However, if the marginal subsidy is not zero, there will be an additional effect on the timing of the investment. For instance, if the marginal subsidy is positive so that a deferral of the investment leads to a higher subsidy, then we would expect the investment trigger to be greater than what is indicated by the first bracket. The second bracket becomes, in this case, greater than one, and the additional delay is achieved. If the marginal subsidy is negative, we obtain the opposite effect.

Technically, Proposition 2.1 is obtained by evaluating the functional forms of the value of the investment opportunity and evaluating a smooth transition to the NPV of the investment (including the subsidy package), which takes place at the investment trigger point. The value

of the investment opportunity is implied by the restriction imposed by Eq. (2.3) and by imposing an additional boundary condition in which the value of the investment opportunity must approach zero as the earnings flow  $y_t$  approaches zero. The latter condition is implied by the fact that the probability that a geometric Brownian motion reaches the investment trigger point is very small if it is sufficiently small.

We also notice that if  $K = 0$  and  $\frac{d}{dy}K = 0$ , the right-hand side is just the unsubsidised investment trigger  $\frac{I}{1-\tau}(r - \mu)\frac{\lambda_1}{\lambda_1 - 1}$ , which has the usual interpretations. The first term  $\frac{I}{1-\tau}(r - \mu)$  is the point where the NPV is exactly zero, and the second term  $\frac{\lambda_1}{\lambda_1 - 1}$  makes the optimal adjustment to take into account the option value of delaying the investment. By receiving a subsidy worth  $K > 0$ , but where  $\frac{d}{dy}K = 0$ , the firm will speed up the investment to a point where the firm would have made an unsubsidised investment costing  $I - K$ , as explained above. Finally, if  $\frac{d}{dy}K \neq 0$ , the firm will also make a further adjustment depending on whether the subsidy will increase or decrease if there is a delay. If  $\frac{d}{dy}K > 0$ , the final term on the right-hand side is greater than one, so the firm will delay the subsidised investment beyond the point at which the value effect is taken into account. If  $\frac{d}{dy}K < 0$ , the firm will speed up the investment. We can think of this final effect as a reward or penalty for delay imposed on the firm depending on whether the subsidy will increase or decrease, respectively, with the market conditions. This effect implies that  $y^{**}$  may be greater than or less than the unsubsidised investment trigger  $y^*$ , even if we set  $K(y^*) = 0$ . For instance, if  $\frac{d}{dy}K(y^*) > 0$ , the firm will delay the investment beyond the unsubsidised investment trigger  $\frac{I}{1-\tau}(r - \mu)\frac{\lambda_1}{\lambda_1 - 1}$ . Pennings (2000) suggested that offering a negative tax relief for FDI investments (i.e.,  $\delta < 0$ ) to finance an investment support package (i.e.,  $\Delta > 0$ ), which is self-financing at the unsubsidised investment point  $y^*$ , will delay the investment trigger point beyond  $y^*$ . This is because we can write, with  $\Delta > 0$  and  $\delta < 0$  constant, the value of the

subsidy as  $K(y_t) = \Delta + \frac{\delta y_t}{r-\mu}$ , and if we calibrate the package such that  $\Delta + \frac{\delta y^*}{r-\mu} = 0$  it becomes self-financing at the optimal trigger point  $y^*$ . Since the derivative is  $\frac{d}{dy_t}K(\Delta, \delta) = \frac{\delta}{r-\mu}$ , which is positive, the firm will delay the investment beyond  $y^*$ . It is possible, therefore, to reduce the investment support  $\Delta$  by a small amount to restore investment at the unsubsidised trigger point  $y^*$ , and there is, in this case, rent extraction equal to the reduction in  $\Delta$ . We argue later that this strategy is unlikely to be credible. The country effectively offers a subsidy with a negative value at  $y^{**} = y^*$ , based on the assumption that the firm maximises the value of the ‘investment plus subsidy’ over all possible trigger points. This implicitly assumes that the firm believes that if it makes the investment at a point  $y < y^*$  it would actually receive the NPV plus an even smaller subsidy (since the value of the subsidy is increasing in  $y_t$ ). However, in this region, the firm would simply prefer to hold on to the value of the investment opportunity, ignoring the subsidy. Therefore, this particular subsidy package violates the constraint that  $V(y_t|t < \tau_2, \text{Subsidy}) \geq V(y_t|t < \tau_1)$ . We explore what implications this has on optimal subsidy design below.

**Proposition 2.2:** *Let  $y^*$  be the investment trigger point of a firm that receives no investment subsidy. If the host country wants to speed up the investment trigger point from  $y^*$  to  $y^{**} \leq y^*$  the investment subsidy  $K(y^{**})$  must satisfy the ordinary differential equation (ODE):*

$$\frac{d}{dy_t}K(y^{**}) - \frac{\lambda_1}{y^{**}}K(y^{**}) = \lambda_1 I \left( \frac{1}{y^*} - \frac{1}{y^{**}} \right). \quad (2.14)$$

*The solution to this problem is the subsidy:*

$$K(y^{**}) = \frac{I}{\lambda_1 - 1} \left( \frac{y^{**}}{y^*} \right)^{\lambda_1} + \left( 1 - \frac{\lambda_1}{\lambda_1 - 1} \frac{y^{**}}{y^*} \right) I, \quad (2.15)$$

where at  $y^{**} = y^*$ ,  $K(y^*) = \frac{d}{dy_t} K(y^*) = 0$  for all  $y^{**} \leq y^*$ ,  $K(y^{**}) \geq 0$ , and  $\frac{d}{dy_t} K(y^{**}) \leq 0$ .

Note that, if we substitute  $y^* = \frac{I}{1-\tau}(r - \mu) \frac{\lambda_1}{\lambda_1 - 1}$  into Eq. (2.15), we can find that  $K(y^{**}) = \frac{I}{\lambda_1 - 1} \left( \frac{y^{**}}{y^*} \right)^{\lambda_1} - \left( \frac{y^{**}(1-\tau)}{r-\mu} - I \right)$ , as shown in Fig. 2.1.

The ODE in Eq. (2.14) arises from the expression for the optimal investment trigger point in Proposition 2.1. The ODE characterises all available trigger points  $y^{**}$  that are available to the firm. If we can find one boundary point on this curve we will have the entire curve. One such boundary point is that the firm receives no subsidy and a second is that it is in the firm's interest to invest at the unsubsidised trigger point  $y^*$ . Therefore, a point on the curve in Eq. (2.14) is that as  $y^{**} = y^*$  and  $K(y^*) = 0$  so that the value of the subsidy is zero, and  $\frac{d}{dy} K(y^*) = 0$  so that there is no effect on the timing of the investment. Taking into account these boundary conditions we find Eq. (2.15). We expect that the effect of the boundary condition is to make the NPV plus the investment subsidy exactly equal to the value of the investment opportunity.

Figure 2.1 shows that if we add  $K(y^{**})$  and  $\left( \frac{y^{**}(1-\tau)}{r-\mu} - I \right)$  together, the value adds up to the value of the investment opportunity exactly. The reason is that the subsidy must compensate the firm for making the investment early such that the combined value of the investment and the subsidy package must at least be equal to the firm's outside option, which is to keep the unsubsidised investment opportunity, but it will never be optimal to compensate the firm more. Therefore, this constraint will always be binding.

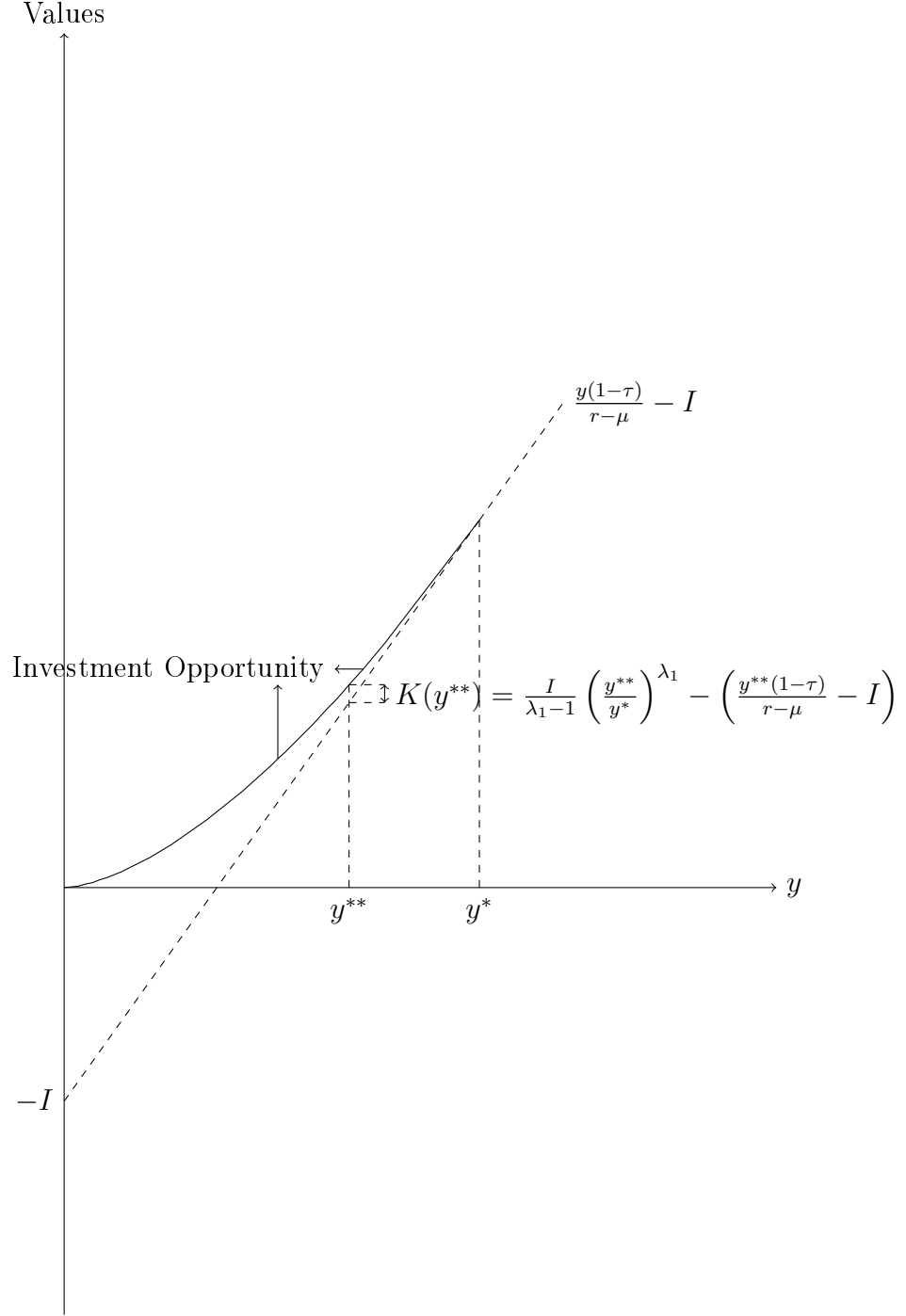


Figure 2.1: If we add  $K(y^{**})$  and  $\frac{y^{**}(1-\tau)}{r-\mu} - I$  together, we find that the value adds up to the value of the investment opportunity  $\frac{I}{\lambda_1 - 1} \left( \frac{y^{**}}{y^*} \right)^{\lambda_1}$ . The reason is that the subsidy must compensate the firm for making the investment sooner and the combined value of the investment and the subsidy must at least be equal to the firm's outside option, which is to wait and keep the investment opportunity. However, it will never be optimal for the host country to compensate the firm more. Therefore, this constraint will always be binding. The parameter values used in this illustration are  $I = 3$ ,  $r = 10\%$ ,  $\mu = 2\%$ ,  $\sigma = 25\%$ , and  $\tau = 20\%$ . In this case,  $y^* = 5.83$  and  $y^{**} = 4$ .



We can look at two special cases. First, suppose the investment support is offered as the only ingredient in the subsidy package such that we can write  $K(\Delta(y_t), \delta(y_t)) = \Delta(y_t)$ . The optimal investment trigger defined by Proposition 2.1 becomes:

$$y^{**} = \left( y^* - \frac{\Delta(y^{**})}{1-\tau} (r-\mu) \frac{\lambda_1}{\lambda_1-1} \right) \left( 1 - \frac{r-\mu}{(1-\tau)(\lambda_1-1)} \Delta'(y^{**}) \right)^{-1}. \quad (2.16)$$

Similarly, suppose that tax relief,  $\delta(> 0)$ , is offered as the only ingredient in the subsidy package. Since  $K(\Delta(y_t), \delta(y_t)) = \frac{\delta(y_t)y_t}{r-\mu}$  in this case, the optimal investment trigger in Proposition 2.1 becomes the following:

$$y^{**} = \left( y^* - \frac{\delta(y^{**})y^{**}}{1-\tau} \frac{\lambda_1}{\lambda_1-1} \right) \left( 1 - \frac{\delta'(y^{**})y^{**} + \delta(y^{**})}{(1-\tau)(\lambda_1-1)} \right)^{-1}. \quad (2.17)$$

Both deliver exactly the same effect on the investment trigger point, at exactly the same cost to the country, depending on  $\Delta(y^{**}) = \frac{\delta(y^{**})y^{**}}{r-\mu}$  and  $\Delta'(y^{**}) = \frac{y^{**}\delta'(y^{**}) + \delta(y^{**})}{r-\mu}$ , so the only problem is to calibrate the responsiveness of the subsidy package correctly to the market conditions  $y_t$ . The following results summarise this calibration process, and this is a direct corollary from Proposition 2.2.

**Corollary 1:** *In the case that  $K(\Delta(y), \delta(y)) = \Delta(y)$ , the optimal investment support  $\Delta(y^{**})$  must satisfy the following ODE:*

$$\frac{d}{dy_t} \Delta(y^{**}) - \frac{\lambda_1}{y^{**}} \Delta(y^{**}) = \lambda_1 I \left( \frac{1}{y^*} - \frac{1}{y^{**}} \right), \quad (2.18)$$

*with the solution:*

$$\Delta(y^{**}) = \frac{I}{\lambda_1-1} \left( \frac{y^{**}}{y^*} \right)^{\lambda_1} + I \left( 1 - \frac{y^{**}}{y^*} \frac{\lambda_1}{\lambda_1-1} \right). \quad (2.19)$$

In the case that  $K(\Delta(y), \delta(y)) = \delta(y)$ , the optimal tax relief  $\delta(y^{**})$  must satisfy the following ODE:

$$\frac{d}{dy_t} \delta(y^{**}) - \frac{\lambda_1 - 1}{y^{**}} \delta(y^{**}) = \frac{\lambda_1 I(r - \mu)}{y^{**}} \left( \frac{1}{y^*} - \frac{1}{y^{**}} \right), \quad (2.20)$$

with the solution:

$$\delta(y^{**}) = \frac{I(r - \mu)}{\lambda_1 - 1} \frac{y^{**\lambda_1 - 1}}{y^{*\lambda_1}} + I(r - \mu) \left( \frac{1}{y^{**}} - \frac{1}{y^*} \frac{\lambda_1}{\lambda_1 - 1} \right). \quad (2.21)$$

The cost to the host country for inducing any investment trigger point  $y^{**}$  is the same regardless of method.

These results are immediate from Proposition 2.2, and given these results, we can justifiably write  $K(y_t)$  instead of  $K(\Delta(y_t), \delta(y_t))$  since it is immaterial how the investment subsidy is implemented as long as the restrictions on  $K$  satisfy Proposition 2.2. We find that the costs of the subsidy to lower the optimal investment trigger to a given target level are the same regardless of the form of the subsidy, counter to the assertions made in Pennings (2000) and Yu *et al.* (2007). The main reason for this is that they assume that the slope of  $K(y)$  is unconstrained, and much of their results hinge on the observation that if the country offers a fixed investment support  $K'(y) = 0$ , whereas if the country offers a tax relief, the slope is  $K'(y) > 0$ . We argue that neither is optimal and that in general  $K'(y) \leq 0$  is in equilibrium. In Fig. 2.2, we illustrate the investment choices in Pennings (2000).

In Fig. 2.2, the result in the work of Pennings (2000) is transparent. Pennings suggested that the host country should impose an extra tax on FDI firms that will fund a package of direct investment support. These measures are denoted as  $\Delta_i^P$  (the investment support) and  $\delta_i^P$  (the extra tax rate) in the figure where the subscript  $i (= 1 \text{ or } 2)$  represents the two cases

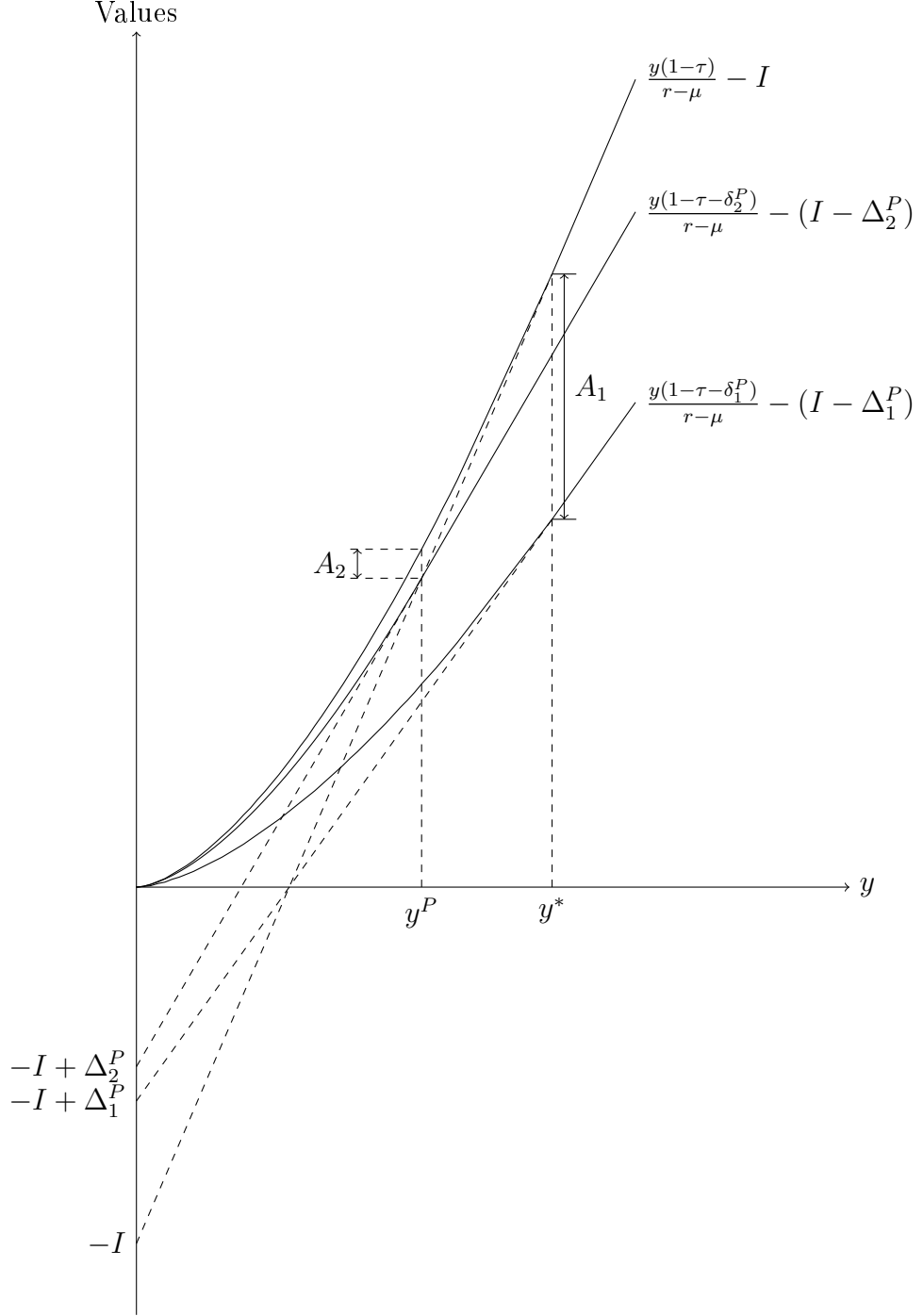


Figure 2.2: The straight line marked  $\frac{y(1-\tau)}{r-\mu} - I$  is the NPV of the unsubsidised investment, and the investment trigger  $y^*$  is the optimal timing of the investment without subsidy. Pennings (2000) demonstrated that the host country can extract rent from the firm by offering a direct investment support (denoted by  $\Delta_1^P$ ) at the same time as increasing the tax rate (denoted by  $\delta_1^P$ ) without changing the optimal investment trigger point. The magnitude of the rent extraction is  $A_1$ . Additionally, Pennings (2000) demonstrated that, by offering a contract that is self-financing, the host country can lower the investment trigger point to  $y^P$  and extract rent. The subsidy is denoted by  $\Delta_2^P$  and  $\delta_2^P$ , and the magnitude of the rent extraction is  $A_2$ . The parameter values used in this illustration are  $I = 5$ ,  $r = 10\%$ ,  $\mu = 2\%$ ,  $\sigma = 25\%$ ,  $\tau = 20\%$ ,  $\Delta_1^P = 3$ , and  $\delta_1^P = 5\%$ . In this case,  $y^* = 5.83$  and  $y^P = 4$ .

analysed by Pennings (2000). As we can see, they will tilt the NPV of the investment such that it becomes flatter, but they will not change the cut-off point where the NPV is zero, and it is in this sense that the package is self-financing. As we can see, the firm will not change investment behaviour, but the profits at the point of investment are lower than the profits at the investment point in an unsubsidised industry. Although the subsidy package is self-financing, it will allow the host country to extract rent from the firm at the optimal investment trigger (denoted by  $A_1$  in Fig. 2.2). If the firm has a choice between receiving a subsidy or not, the firm will be better off declining the offer of a subsidy. In Fig. 2.3, we illustrate the investment choices in Yu *et al.* (2007).

The host country seeks to reduce the investment trigger (such as  $y^Y$  shown in Fig. 2.3) so that the investment is sped up, and the subsidy is either in the form of a direct investment support worth  $\Delta^Y$  or a reduction of the tax rate equal to  $\delta^Y$ . We see the effect of each when the reduction of the investment trigger is exactly the same, and from the figure, we clearly see that the firm can extract higher rent when the host country uses tax relief than when it uses direct investment support.

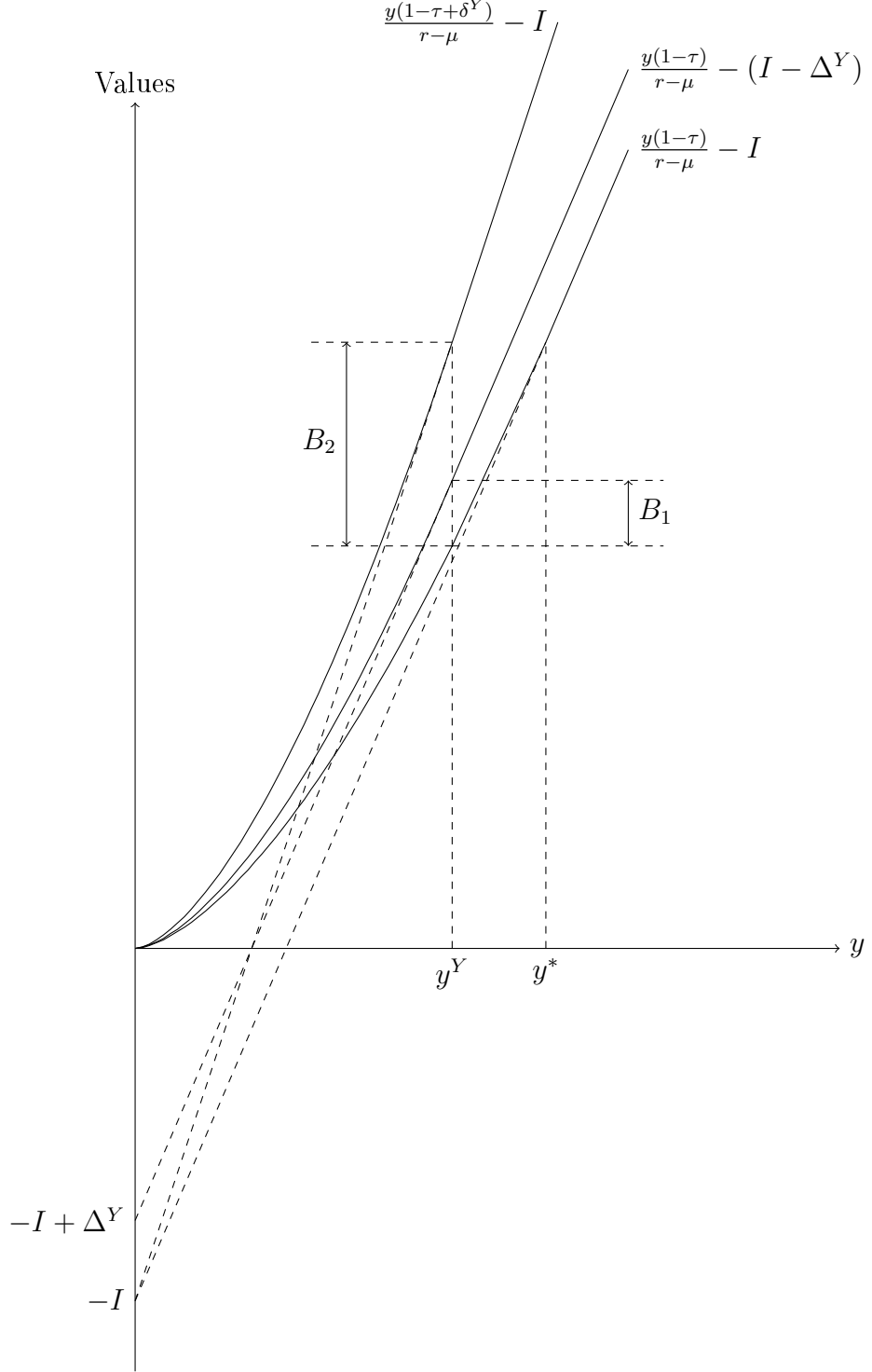


Figure 2.3: The straight line marked  $\frac{y(1-\tau)}{r-\mu} - I$  is the NPV of the unsubsidised investment, and the investment trigger  $y^*$  is the optimal timing of the investment without subsidy. Yu *et al.* (2007) showed that it is cheaper to offer a direct investment subsidy (denoted by  $\Delta^Y$ ) than a tax relief (denoted by  $\delta^Y$ ) if the host country wants to lower the investment trigger to a point  $y^Y < y^*$ . However, both lead to rent extraction by the firm, denoted by  $B_1$  and  $B_2$ , respectively. The parameter values used in this illustration are  $I = 5$ ,  $r = 10\%$ ,  $\mu = 2\%$ ,  $\sigma = 25\%$ ,  $\tau = 20\%$ , and  $\Delta^Y = 2.14$ . In this case,  $y^* = 5.83$  and  $y^Y = 4.5$ .

Pennings (2000) did not consider the unsubsidised investment opportunity as an outside option for the firm, which can be unrealistic. When this option is open to the firm, it would not accept a subsidy that allows the host country to extract rent in the way that is illustrated in Fig. 2.2. Yu *et al.* (2007), on the other hand, did allow the firm to extract rent by exploiting the rigidity of the subsidy package. If the host country is able to adjust its subsidy to the changing market conditions, such extraction can be avoided by allowing  $\Delta$  or  $\delta$  to be functions of  $y_t$ . The optimal packages will exactly match the value of the unsubsidised investment opportunity, thereby offering the firm sufficient rent to meet its incentive compatibility constraint but, at the same time, prevent rent extraction beyond this point.

### 2.3.2 Optimal Timing of Subsidy

The host country receives a welfare benefit  $w$  from the time of the investment, which is the stopping time for the investment trigger point  $y^{**}$  at which the investment takes place at a cost  $K(y^{**})$ , to the time at which the investment would have taken place anyway,  $y^*$ . We find the following result.

**Proposition 2.3:** *Given the investment cost  $I$  and the unsubsidised investment trigger point  $y^*$ , the optimal timing of the investment subsidy  $K(y^{**})$  is given implicitly by the following expression for the subsidy trigger  $y^{**}$ :*

$$y^{**} = y^* \max \left( 0, 1 - \frac{w}{rI} \right). \quad (2.22)$$

*Everything else being equal, the closer  $y^{**}$  is to  $y^*$ , the greater the investment cost  $I$  and the lower the welfare flow  $w$ . The welfare at the time the subsidy is offered is  $W(y^{**}) =$*

$$\frac{w}{r} \left( 1 - \left( \frac{y^{**}}{y^*} \right)^{\lambda_1} \right) - K(y^{**}).$$

The functional form of the welfare of the option to offer investment subsidy is implied by the conditions in Eq. (2.3). The optimal timing of the investment subsidy can be found by evaluating the point at which the welfare of the option to offer subsidy achieves a smooth transition to the welfare of the investment. Additional boundary conditions are found by evaluating the welfare of the subsidy option as the earnings flow is sufficiently close to zero, as there are two possibilities in this case. Either the subsidy trigger is zero and no smooth transition to the welfare of the investment is found, or there is no likelihood that the subsidy trigger is reached. At the time the subsidy is offered, the welfare is the expected value of the welfare flow  $w$ , which equals the first term in the expression for  $W(y^{**})$  minus the value of the subsidy package, which is the second term.

A starting point for a discussion about this result is the ratio  $\frac{w}{rI}$ . The numerator is the welfare flow that arises from the investment, and the denominator is the capital flow that is necessary to justify the investment cost  $I$ . If this ratio is greater than one, the welfare flow  $w$  dominates the capital flow  $rI$ , so investment can be justified on welfare grounds even if the earnings flow is zero. In this case, we will always find that the optimal timing is  $y^{**} = 0$ . When this is not satisfied, the optimal timing is positive so that  $y^{**} > 0$ , but it will always be less than the unsubsidised trigger point  $y^*$ . Therefore, as long as there is a positive incremental welfare benefit, it will always be optimal to offer a subsidy package that speeds up the investment. What we find is that the sooner the optimal subsidy is offered, the greater the welfare flow  $w$  and later the greater the capital flow  $rI$ , everything else being equal. Figure 2.4 illustrates the timing problem.

In Fig. 2.4, the host country must find the optimal timing of the transition from holding

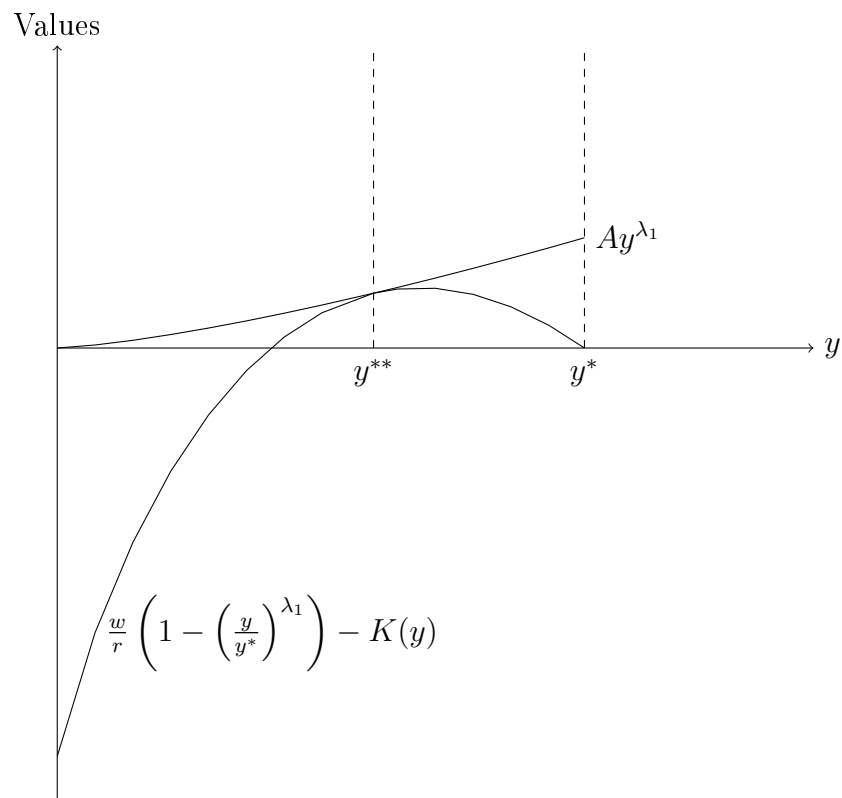


Figure 2.4: Optimal timing of investment subsidy. The investment trigger  $y^*$  is the unsubsidised investment trigger, and the investment trigger  $y^{**}$  is the optimal subsidised investment trigger. The parameter values used in this illustration are  $I = 5$ ,  $r = 10\%$ ,  $w = 0.48$ ,  $\mu = 2\%$ , and  $\sigma = 25\%$ . In this case,  $y^* = 6.972$  and  $y^{**} = 4.183$ .



the option to offer a subsidy to offering the subsidy and attracting an investment. The incremental welfare is the value of attracting the investment before market conditions lead to it being made in the first place, so the incremental welfare goes to zero when the subsidised investment trigger  $y^{**}$  approaches the unsubsidised investment trigger  $y^*$ . If  $y_t = 0$  and unsubsidised investment will never take place, a subsidy will be offered if the welfare benefit  $\frac{w}{r}$  is greater than the subsidy  $K(0) = I$ . This corresponds to a situation in which  $w > rI$ , and we see that  $y^{**}$ , in this case, is zero. In the figure, we are given a situation where  $w < rI$ , and in this case,  $y^{**} > 0$ .

### 2.3.3 Preemption Risk

We now take into account preemption risk. When firms are competing to invest in a single country, preemption risk in the market for investment can loosely be defined as the negative externality on the value of other firms' investments arising from the event that the firm makes an investment. When countries are competing to attract an investment to their own locations, preemption risk in the market for subsidy is the externality on other countries' welfare arising from the event that a given country successfully attracts business through a subsidy package.

The first problem is studied by Lambrecht and Perraudin (2003), and if we assume there is preemption risk in the market for investment, we can use Lambrecht and Perraudin's (2003) results directly. To introduce incomplete information, they assume that a firm conjectures that its competing firm makes an investment when  $y_t$  crosses some level  $y_C^*$  for the first time, and  $y_C^*$  is independently drawn from a probability distribution  $F(y_C^*)$ . They define  $h_F(y_C^*) = \frac{f(y_C^*)}{1-F(y_C^*)}$  as the hazard rate at which the investment will be made by the competitors in the next increment  $dy$ , conditional on the event that it has not yet happened ( $f(y)$  is the

density function  $f(y) = \frac{d}{dy}F(y)$ ). They found that the unregulated investment trigger point for a firm is the following:

$$y^* = \frac{I}{1 - \tau}(r - \mu) \frac{\lambda_1 + y^* h_F(y^*)}{\lambda_1 - 1 + y^* h_F(y^*)}. \quad (2.23)$$

When the hazard rate goes to zero, the investment trigger will converge to the ‘normal’ trigger point in Eq. (2.4).

It shows that, when there is preemption risk in the market for investment, the investment trigger point is lowered, and the value of the investment opportunity is affected. Proposition 2.2 still applies; however, so the functional form of the investment subsidy is still given by  $K(y^{**}) = \frac{I}{\lambda_1 - 1} \left( \frac{y^{**}}{y^*} \right)^{\lambda_1} + \left( 1 - \frac{\lambda_1}{\lambda_1 - 1} \frac{y^{**}}{y^*} \right) I$ , and only the unsubsidised investment trigger  $y^*$  is now given by Eq. (2.23). The country will, for the desired timing  $y^{**}$ , offer a subsidy  $K(y^{**})$  such that the value of the investment opportunity (under preemption risk) exactly matches the NPV of the investment project plus the value of the subsidy. We find the following result.

**Proposition 2.4:** *An increase in the preemption risk in the market for investment that lowers the unsubsidised investment trigger point  $y^*$  will also lead to a lowering of the subsidy trigger point  $y^{**}$  for  $\frac{w}{rI} < 1$ . There is, moreover, no loss in the incremental welfare of the optimal investment subsidy at the optimal subsidy trigger  $y^{**}$  (i.e., the welfare  $W(y^{**})$  does not depend on  $y^*$ ).*

The case in which  $\frac{w}{rI} \geq 1$  is in this context is not very interesting since, in this case, the subsidy trigger is always minimal and  $y^{**} = 0$ . Therefore, the result focuses on the converse case. Proposition 2.4 is illustrated in Fig. 2.5.

We see that the subsidy trigger  $y^{**}$  is lowered when firms compete in the market for

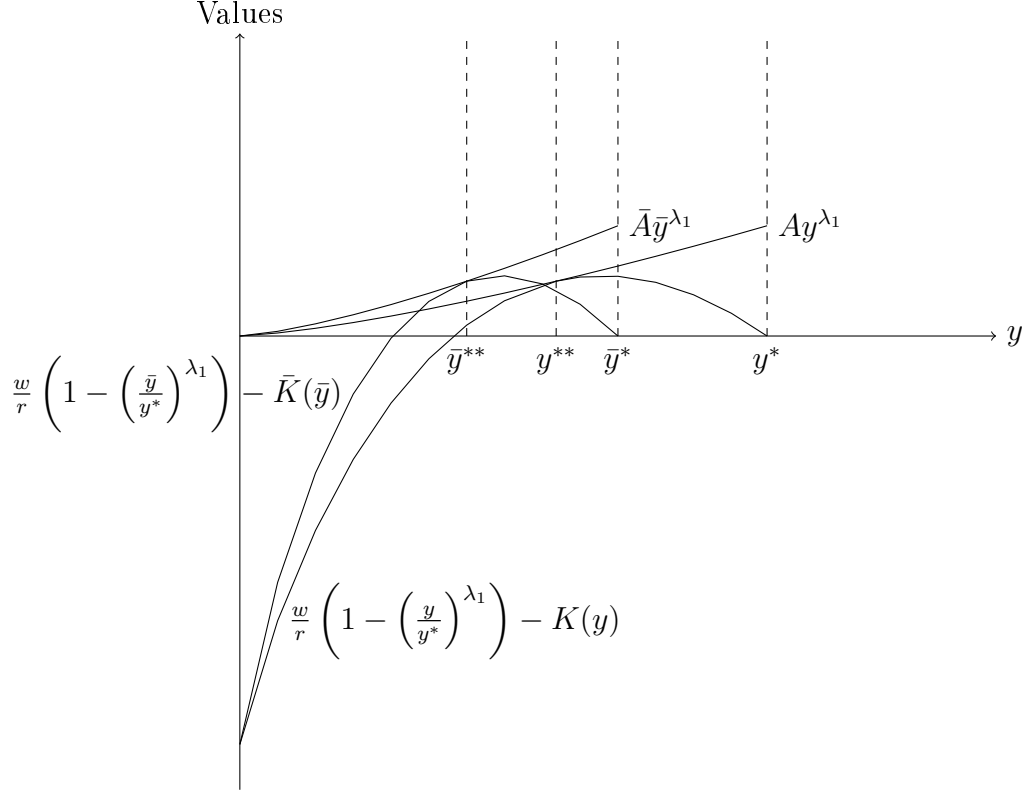


Figure 2.5: The effect of preemption risk between firms on the optimal timing of investment. We use  $y^*$  to denote the investment trigger,  $y^{**}$  to denote the subsidy trigger,  $Ay^{\lambda_1}$  to denote the welfare of the option to offer subsidy, and  $\frac{w}{r} \left(1 - \left(\frac{y}{y^*}\right)^{\lambda_1}\right) - K(y)$  to denote the welfare of the investment subsidy when there is no preemption risk. The corresponding notation for the case of preemption risk is  $\bar{y}^*$ ,  $\bar{y}^{**}$ ,  $\bar{A}\bar{y}^{\lambda_1}$ , and  $\frac{w}{r} \left(1 - \left(\frac{\bar{y}}{y^*}\right)^{\lambda_1}\right) - \bar{K}(\bar{y})$ , respectively. The parameter values used in this illustration are  $I = 5$ ,  $r = 10\%$ ,  $w = 0.48$ ,  $\mu = 2\%$ , and  $\sigma = 25\%$ . The hazard rate,  $h_F(y^*)$ , is assumed to be 0.1. In this case,  $y^* = 6.972$ ,  $y^{**} = 4.183$ ,  $\bar{y}^* = 5$ , and  $\bar{y}^{**} = 3$ .

investment but that the welfare benefit at the optimal subsidy trigger remains at a constant level. The reason this is the case is best understood in the relationship between the unsubsidised investment trigger  $y^*$  and the subsidy trigger  $y^{**}$ . Since the welfare benefits depend on the incremental welfare from influencing the timing of investment, they depend on the ratio  $\frac{y^{**}}{y^*}$  only and not on the levels of  $y^*$  and  $y^{**}$ . This relationship is not affected by the preemption risk in the market for investment, as Proposition 2.3 still applies. Thus, although  $y^*$  is affected by the preemption risk, the welfare benefits remain constant.

Next, consider that there is preemption risk in the market for subsidy. Consider the probability distribution function  $G$  defined by:

$$G(y) = \mathbb{P}(\text{Subsidy of a competing country is offered at } y_t \leq y). \quad (2.24)$$

Define further  $\bar{y}_t = \max_{0 \leq x \leq t} y_t$  as the ‘all time high’ of the earnings process  $y_s$  up to and including time  $t$ . If no subsidy has been offered at time  $t$ , we know that the probability that the subsidy is offered at earnings levels  $\bar{y}_t$  is zero. The conditional probability  $G(y|\bar{y}_t)$  and  $y \geq \bar{y}_t$  is then defined as:

$$G(y|\bar{y}_t) = \frac{G(y) - G(\bar{y}_t)}{1 - G(\bar{y}_t)}. \quad (2.25)$$

Let  $y^{**}$  be the trigger point for offering a subsidy and let  $\tau_2$  be the stopping time for the event that  $y_t = y^{**}$  for the first time and  $\tau_1$  be the stopping time for the event that the unsubsidised investment trigger  $y_t = y^* > y^{**}$  is reached for the first time. The value of the option to offer a subsidy at the trigger point  $y^{**}$  is then:

$$W(y_t|t \leq \tau_2, \bar{y}_t) = \left(1 - \frac{G(y_t) - G(\bar{y}_t)}{1 - G(\bar{y}_t)}\right) \mathbb{E} \left( \int_{\tau_2}^{\tau_1} e^{-r(s+\tau_2)} w ds - e^{-r\tau_2} K(y^{**}) \right), \quad (2.26)$$

where the right-hand side is the probability of having the winning subsidy at the trigger

point  $y^{**}$  times the welfare of the winning subsidy. The event that somebody else has the winning subsidy leads to zero welfare. We find the following result.

**Proposition 2.5** *The optimal timing  $y^{**}$  of an investment subsidy is given implicitly by the following equation:*

$$\frac{w}{r} + \frac{y^{**}}{\lambda_1} h_G(y^{**}) \left( \frac{w}{r} \left( 1 - \left( \frac{y^{**}}{y^*} \right)^{\lambda_1} \right) - K(y^{**}) \right) = I \left( 1 - \frac{y^{**}}{y^*} \right), \quad h_G(y^{**}) = \frac{g(y^{**})}{1 - G(y^{**})}. \quad (2.27)$$

When there is no preemption risk in the market for subsidy, the left-hand side equals  $\frac{w}{r}$  and the condition above implies Proposition 2.3. When the hazard rate  $h_G(y^{**}) > 0$  is increasing in  $y^{**}$ , the ratio  $\frac{y^{**}}{y^*}$  is either zero or  $\frac{y^{**}}{y^*} < 1 - \frac{w}{rI}$ . The welfare at the time when the subsidy is offered is  $W(y^{**}) = \frac{w}{r} \left( 1 - \left( \frac{y^{**}}{y^*} \right)^{\lambda_1} \right) - K(y^{**})$  and is therefore unaffected by the preemption risk.

The effect of the preemption risk is to speed up the timing of offering the subsidy. The ratio  $\frac{y^{**}}{y^*}$  is lowered relative to the level we would expect without preemption risk, which we can see from the fact that the second term on the left-hand side is positive except in the special case where the welfare  $W(y^{**}) = 0$ . This implies that the ratio  $\frac{y^{**}}{y^*}$  is lower with preemption risk and that the welfare  $W(y^{**})$  is lower with preemption risk, relative to what it would be without the preemption risk.

Proposition 2.2, which sets out the form of the optimal subsidy  $K(y^{**})$ , is therefore robust to preemption risk in the sense that the functional form of  $K$  remains intact, but the ratio  $\frac{y^{**}}{y^*}$  which enters the expression for  $K$  may change. If there is preemption risk in the market for investment, the ratio  $\frac{y^{**}}{y^*}$  will not change, and the required subsidy remains exactly the

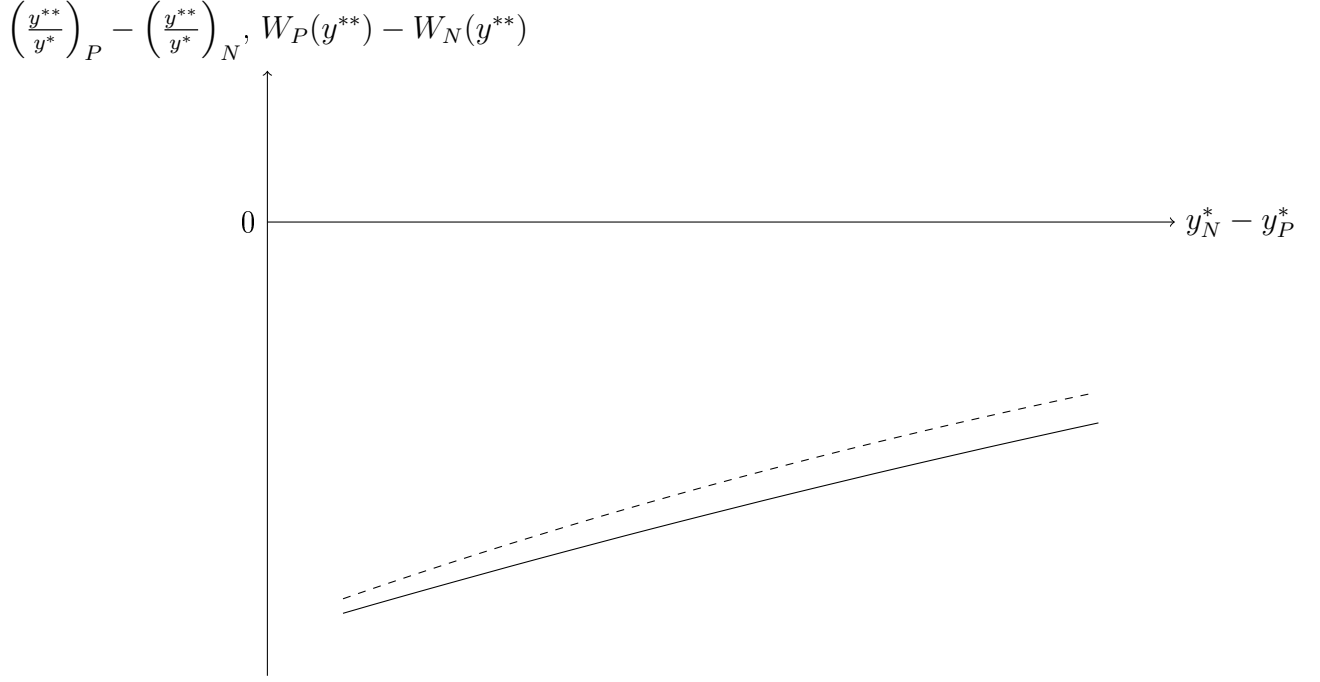


Figure 2.6: The effect of preemption risk in the market for subsidy. The  $x$ -axis measures the degree to which there is preemption risk in the market for investment measured by the difference between the unsubsidised investment trigger without ( $N$ ) and with ( $P$ ) preemption risk, and the  $y$ -axis measures the effect of preemption risk in the market for subsidy on the ratio  $\frac{y^{**}}{y^*}$  and the welfare  $W(y^{**})$  with ( $P$ ) and without ( $N$ ) preemption risk. The solid lines show the results for the  $\frac{y^{**}}{y^*}$ -ratio and the dashed lines show the results for the welfare  $W(y^{**})$ . The parameter values used in this illustration are  $I = 5$ ,  $r = 10\%$ ,  $w = 0.48$ ,  $\mu = 2\%$ , and  $\sigma = 25\%$ . The hazard rate,  $h_G(y)$ , is assumed to equal  $\frac{1}{a-y}$  and  $a$  is assumed to be 5.

same. If there is preemption risk in the market for subsidy, the ratio  $\frac{y^{**}}{y^*}$  will be lowered, but the functional form of the investment subsidy will remain as outlined in Proposition 2.2. Thus, the only effect on  $K$  comes from the lowering of this ratio.

It is difficult to find analytical expressions for the ratio  $\frac{y^{**}}{y^*}$  and the welfare  $W(y^{**})$  since  $y^{**}$  is a root of a high order polynomial, but by making assumptions about the hazard rate  $h_G(y)$ , we can evaluate them numerically. Assume that the hazard rate is increasing in  $y$  and given by the function  $h_G(y) = \frac{1}{a-y}$  for some  $a > 0$ . We then evaluate Eq. (2.27), and the results are given in Fig. 2.6.

The figure shows that the effect of preemption risk in the market for subsidy lowers the subsidy trigger further relative to the situation in which there is no preemption risk but that

the effect is smaller if preemption risk already exists in the market for investment. The same pattern holds for the welfare of subsidy, which is lower when there is preemption risk in the market for subsidy, but the effect is again smaller if preemption risk already exists in the market for investment.

## 2.4 Empirical Predictions for FDI Subsidy

Our model will predict the likelihood of the event that subsidy packages are offered. For example, if we are experiencing market conditions  $y_t < y^{**}$ , the likelihood that a subsidy is made depends on the distance between  $y_t$  and the subsidy trigger  $y^{**}$ . When the level of the subsidy trigger  $y^{**}$  is lowered in an industry relative to another industry, we expect that we are more likely to observe a subsidy offered in that industry. This effect can arise in two ways. First, it can arise from the fact that the unsubsidised investment trigger  $y^*$  is lowered relative to another industry, but that the relative level  $\frac{y^{**}}{y^*}$  remains constant. This is an industry-related effect on FDI subsidy. Second, it can arise from the fact that the relative level  $\frac{y^{**}}{y^*}$  is lowered. This effect arises in the context of parameters describing the market for subsidy and is therefore a subsidy market-related effect on FDI subsidy.

### 2.4.1 Industry-Related Subsidy Effects

The unsubsidised investment trigger is lowered by the degree to which there is competition in the form of preemption risk in the market for investment. When firms compete for investments more strongly, the unsubsidised investment trigger  $y^*$  is lowered, and this has a direct knock-on effect on the subsidy trigger  $y^{**}$ . The ratio  $\frac{y^{**}}{y^*}$  remains constant, but the lowering of the unsubsidised investment trigger also feeds directly into a lowering of the subsidy trigger.

This means that we should expect to see investment subsidy in industries where there is preemption risk. As mentioned before, preemption risk will not change the earnings flow or product prices, so it is a special type of competition that dissipates industry profits by lowering the likelihood that the firm makes an investment rather than reduces the profits of the firms that do make the investment.<sup>1</sup> Therefore, we should be able to talk specifically about the kind of industries where the preemption risk in the market for investment is high. The industries affected by investment are those in which the investment by one firm has a negative externality on the investments that could be made by others. This necessitates that the industry is made up by a relatively small number of large firms where investments have strategic commitment value, defined as the value of making an investment that discourages others from investing in the same industry. This points to a symbiotic relationship between firms that are keen to build capacity in an industry, which may not have great short-term financial profit potential but could be strategically important in the longer run, and countries that are keen to attract investments from overseas.

## 2.4.2 Subsidy Market-Related Effects

The ratio of the subsidy trigger over the unsubsidised investment trigger,  $\frac{y^{**}}{y^*}$ , is lowered in two ways. First, it depends on the factor  $\frac{w}{rI}$ , which is the ratio of the welfare flow that is a result of attracting investment  $w$ , and the amortised investment cost  $rI$ . When this ratio is high, the ratio  $\frac{y^{**}}{y^*}$  is likely to be low. Investment subsidy is likely to be targeted to locations and industries where the welfare benefits are the greatest relative to the amortised investment cost. We should expect that investment subsidy is used to attract businesses to areas where there is a lack of jobs (i.e., where the welfare benefit  $w$  is large). Note that

---

<sup>1</sup>The case in which competition leads to lower earnings and product prices needs separate rigorous treatment, which we do not provide here. We leave a study of this type of competition to future research.



the value of this welfare benefit is measured as the incremental welfare of attracting the investment to the host country, relative to the unsubsidised investment trigger  $y^*$ , at which the investment would have taken place in any event.

Thomas (2007) carried out a case study of the investment support for the call centre business (customer support centres), which is a very labour-intensive business with relatively low setup cost. The amortised investment cost in this industry is likely to be linked to the wage level in the location where the business is located. We expect, therefore, that the locations that call centres are likely to be attracted into are areas where the unemployment is high and the wages are low. Thomas (2007) found that subsidies for call centre locations have been offered even for Indian call centres where wages are already very low.

Second, the ratio  $\frac{y^{**}}{y^*}$  depends on the degree to which there is preemption risk in the market for subsidy. Competition between countries in the form of preemption risk will, therefore, also increase the likelihood of observing subsidy as a means of attracting FDI projects. Thomas (2007) carried out several case studies of bidding wars in the biofuel production industry, microchip manufacturing industry, and automotive industry. The biofuel production industry is predominantly capital intensive and will not generate a large number of jobs. However, there are only so many production facilities being planned at any one point in time, and once a location decision is made, it is unlikely that other locations will be able to attract a similar investment. This will also be true for the microchip manufacturing and automotive industries. The bidding wars that Thomas (2007) reported in these instances can, therefore, be explained by the preemption risk in the market for subsidy that is linked to these kinds of investments.

## 2.5 Conclusion

In this chapter, we study the optimal design and timing of FDI subsidy, and how competition between firms seeking investment subsidy and countries offering investment subsidy affect the two. We derive the optimal timing and value of the subsidy package and find that preemption risk in the market for investment leads to industries where there are first-mover advantages in the investment process, which are more likely to attract FDI subsidy than other industries. We also find that investments that create a large welfare benefit relative to the amortised investment cost are also attractive targets for FDI subsidy. Finally, we find that preemption risk in the market for subsidy leads to industries where there are first-mover advantages of subsidy offers, which are more likely to attract FDI subsidy than other industries.

We find that the implementation of the optimal investment subsidy package, exemplified by the choice between offering a front-loaded investment support or a back-loaded tax relief, plays no role. The form of FDI subsidy matters, however, in the sense that the investment subsidy should deter the delay of investment to some degree, implying that the firm will receive a smaller subsidy if it postpones investment in order to benefit from improved market conditions.

We can apply our model to any kind of investment subsidy, and in the introduction, we mention the example of subsidy to promote investments in a switch from traditional to green technology. Many of the issues that arise in this area are similar to the issues that arise in the FDI market, and we can transfer the results we obtain for FDI directly. There are, however, interesting additional effects in the market for green investments. For instance, the welfare benefits from a switch to green technology are likely to be global rather than national; therefore, free riding between countries is likely. Dutz and Sharma (2012)

pointed to the fact that most governmental support for research and development in green technology has taken place in Western developed nations. Therefore, to fully study the optimal subsidy of investments in a switch to green technology necessitates, a more complex modelling environment that goes beyond the scope of this thesis may be needed.

## 2.6 Appendix

**Proof of Proposition 2.1:** The firm regards the subsidy package as just another investment or borrowing opportunity, the NPV of which can be maximised by optimal timing. The investment opportunity (prior to investment) takes values that can be expressed as  $Ay_t^{\lambda_1}$  for some constant  $A$ , and the NPV of the investment (at the point of investment) including the value of subsidy package is

$$\left( \frac{y_t(1-\tau)}{r-\mu} - I \right) + K(y_t). \quad (2A.1)$$

The firm decides on the optimal timing when the value of the investment opportunity equals the NPV of investment, and when there is a smooth fit at the investment trigger point. This yields two equations that determine the optimal investment trigger point  $y^{**}$  and the free constant  $A$ . The conditions are as follows:

$$Ay^{**\lambda_1} = \left( \frac{y^{**}(1-\tau)}{r-\mu} - I \right) + K(y^{**}), \quad (2A.2.a)$$

$$\lambda_1 Ay^{**\lambda_1-1} = \frac{1-\tau}{r-\mu} + \frac{d}{dy_t} K(y^{**}). \quad (2A.2.b)$$

Solving for  $A$  and  $y^{**}$  simultaneously gives the result.  $\square$

**Proof of Proposition 2.2:** Equation (2.14) follows directly from Eqs. (2A.2.a-b). Equation (2.15) follows from the solution to a linear first order ODE, which implies that:

$$K(y) = Cy^{\lambda_1} + I \left( 1 - \frac{\lambda_1}{\lambda_1 - 1} \frac{y^{**}}{y^*} \right) \quad (2A.3),$$

where  $C$  is an integration constant. We use the constraint that  $V(y_t|t < \tau_2, \text{Subsidy}) \geq V(y_t|t < \tau_1)$ . Since the problem is the same along all investment trigger points  $y^{**}$ , we only

need to fit one boundary condition, and we can fit the ODE to the point  $y^{**} = y^*$  and  $K(y^*) = \frac{d}{dy}K(y^*) = 0$ , which yields the solution

$$C = \frac{I}{\lambda_1 - 1} (y^*)^{-\lambda_1} \quad (2A.4).$$

By substituting  $C$  back in the expression for  $K(y)$  the result follows.  $\square$

**Proof of Proposition 2.3:** Using arguments outlined in Section 2, we can write  $W(y_t|t \geq \tau_2) = Ay_t^{\lambda_1} + By_t^{\lambda_2} + \frac{w}{r}$  for arbitrary constants  $A$  and  $B$ . We know that  $\lim_{y_t \rightarrow 0} W(y_t|t \geq \tau_2) = \frac{w}{r}$  since there is no likelihood that  $\tau_1$  will be reached at this limit point, and this implies that  $B = 0$ . Additionally, we know that  $\lim_{y_t \rightarrow y^*} W(y_t|t \geq \tau_2) = 0$  since there is no likelihood that the welfare flow will continue, and this implies that  $A = -\frac{w}{r} \left(\frac{1}{y^*}\right)^{\lambda_1}$ . This implies that  $W(y_t|t \geq \tau_2) = \frac{w}{r} \left(1 - \left(\frac{y^{**}}{y^*}\right)^{\lambda_1}\right)$ . If we look at the time prior to  $\tau_2$ , we find that  $W(y_t|t < \tau_2) = A'y_t^{\lambda_1} + B'y_t^{\lambda_2}$ . Moreover,  $B'$  must vanish because  $\lim_{y_t \rightarrow 0} W(y_t|t < \tau_2) = 0$ , so the value-matching condition and the smooth-pasting condition imply the following system, where  $y^{**}$  is the solution:

$$W(y_t|t < \tau_2) = A'y^{**\lambda_1} = \frac{w}{r} \left(1 - \left(\frac{y^{**}}{y^*}\right)^{\lambda_1}\right) - K(y^{**}) \quad (2A.5.a)$$

$$\begin{aligned} \frac{d}{dy_t} W(y_t|t < \tau_2) &= \lambda_1 A' y^{**\lambda_1 - 1} = \frac{d}{dy_t} \left( \frac{w}{r} \left(1 - \left(\frac{y^{**}}{y^*}\right)^{\lambda_1}\right) - K(y^{**}) \right) \\ &= -\lambda_1 \frac{w}{r} \left(\frac{y^{**}}{y^*}\right)^{\lambda_1 - 1} \frac{1}{y^*} - \frac{\lambda_1}{\lambda_1 - 1} I \left(\frac{y^{**}}{y^*}\right)^{\lambda_1 - 1} \frac{1}{y^*} + \frac{\lambda_1}{\lambda_1 - 1} \frac{I}{y^*}. \end{aligned} \quad (2A.5.b)$$

Combining the two equations and eliminating  $A'$ , we find the solution:

$$y^{**} = y^* \max \left( 0, 1 - \frac{w}{rI} \right) \quad (2A.6).$$

The results follow.  $\square$

**Proof of Proposition 2.4:** The first part is obvious from (21):  $\frac{dy^{**}}{dy^*} = \left(1 - \frac{w}{rI}\right) > 0$  for  $\frac{w}{rI} <$

1. The second part can be evaluated by evaluating the derivative  $\frac{dW(y^{**}(y^*))}{dy^*} = \frac{\partial W}{\partial y^{**}} \frac{\partial y^{**}}{\partial y^*} + \frac{\partial W}{\partial y^*}$ .

We find that  $\frac{\partial y^{**}}{\partial y^*} = \left(1 - \frac{w}{rI}\right)$  and that:

$$\frac{\partial W}{\partial y^{**}} \frac{\partial y^{**}}{\partial y^*} = -\lambda_1 \left( \frac{w}{r} + \frac{I}{\lambda_1 - 1} \right) \frac{1 - \frac{w}{rI}}{y^*} \left( \frac{y^{**}}{y^*} \right)^{\lambda_1 - 1} + \lambda_1 \frac{I}{\lambda_1 - 1} \frac{1 - \frac{w}{rI}}{y^*} \quad (2A.7)$$

$$\frac{\partial W}{\partial y^*} = \lambda_1 \left( \frac{w}{r} + \frac{I}{\lambda_1 - 1} \right) \frac{y^{**}}{y^{*2}} \left( \frac{y^{**}}{y^*} \right)^{\lambda_1 - 1} - \lambda_1 \frac{I}{\lambda_1 - 1} \frac{y^{**}}{y^{*2}}. \quad (2A.8)$$

By combining terms, we find  $\frac{dW}{dy^*}$ , and we find:

$$\frac{y^{*2}}{I y^{**}} \frac{dW}{dy^*} = \frac{\lambda_1}{\lambda_1 - 1} \left( \left( \left(1 - \frac{w}{rI}\right) \frac{y^*}{y^{**}} - 1 \right) \left( 1 - \left( \frac{y^{**}}{y^*} \right)^{\lambda_1 - 1} \right) - \frac{\lambda_1 w}{rI} \left( \left(1 - \frac{w}{rI}\right) \frac{y^*}{y^{**}} - 1 \right) \left( \frac{y^{**}}{y^*} \right)^{\lambda_1 - 1} \right) \quad (2A.9).$$

However, since  $\frac{y^*}{y^{**}} = \left(1 - \frac{w}{rI}\right)^{-1}$ , the right-hand side is zero. Hence,  $\frac{dW}{dy^*} = 0$ .  $\square$

**Proof of Proposition 2.5:** The value of the option to offer subsidy at time  $t$ , conditional on the all-time-high earnings level  $\bar{y}_t$ , can now be written as  $Ay_t^{\lambda_1}$  for some constant  $A$ . At the optimal time of subsidy, this value smooth pastes into the welfare of the investment subsidy  $(1 - G(y_t|\bar{y}_t)) \left( \frac{w}{r} \left( 1 - \left( \frac{y^{**}}{y^*} \right)^{\lambda_1} \right) - K(y^{**}) \right)$ . We find, therefore, the following two

conditions:

$$Ay^{**\lambda_1} = (1 - G(y^{**}|\bar{y}_t))\frac{w}{r} \left( 1 - \left( \frac{y^{**}}{y^*} \right)^{\lambda_1} \right) - K(y^{**}), \quad \bar{y}_t = y^{**}, \quad G(y^{**}|\bar{y}_t) = 0 \quad (2A.10)$$

$$\lambda_1 Ay^{**(\lambda_1-1)} = -\frac{g(y^{**})}{1 - G(y^{**})} \left( \frac{w}{r} \left( 1 - \left( \frac{y^{**}}{y^*} \right)^{\lambda_1} \right) - K(y^{**}) \right) - \lambda_1 \frac{w}{r} \left( \frac{y^{**}}{y^*} \right)^{\lambda_1-1} \frac{1}{y^*} - \frac{d}{dy} K(y^{**}). \quad (2A.11)$$

Combining the two expressions, we find the expression:

$$\frac{w}{r} + \frac{y^{**}}{\lambda_1} \frac{g(y^{**})}{1 - G(y^{**})} \left( \frac{w}{r} \left( 1 - \left( \frac{y^{**}}{y^*} \right)^{\lambda_1} \right) - K(y^{**}) \right) = K(y^{**}) - \frac{y^{**}}{\lambda_1} \frac{d}{dy} K(y^{**}) \quad (2A.12).$$

Since the preemption risk in the market for subsidy will not affect the subsidy itself, the right-hand side equals  $I \left( 1 - \frac{y^{**}}{y^*} \right)$ . The result follows.  $\square$

## 2.7 Guide to Notation

The table below lists the notation used in this chapter in order of appearance in the text.

Notation	Interpretation
$I$	Investment cost
$y_t$	Earnings flow at time $t$
$\tau$	Corporate tax rate
$y^*$	Optimal investment trigger for unsubsidised investment
$r$	Instantaneous discount rate
$V(y_t t < \tau_1)$	Value of the unsubsidised investment opportunity prior to the stopping time $\tau_1$
$\tau_1$	Stopping time for the event that $y_t = y^*$ for the first time
$V(y_t t \geq \tau_1)$	Value of the earnings flow $y_t$ after the stopping time $\tau_1$
$\mathbb{L}$	Infinitesimal operator associated with the Brownian motion governing the earnings process
$\mathbb{I}$	Identity operator
$K$	Subsidy package consisting of a lump sum support and a tax relief
$\Delta$	Lump sum support
$\delta$	Tax relief
$\Delta(y_t)$	Lump sum support whose value fluctuates with the earnings level $y_t$
$\delta(y_t)$	Tax relief whose value fluctuates with the earnings level $y_t$



---

$K(\Delta(y_t), \delta(y_t))$	Subsidy package whose value fluctuates with the earnings level $y_t$
$\tau_2$	Stopping time when the subsidy is accepted and the investment is made
$V(y_t t < \tau_2, Subsidy)$	Value of the investment opportunity of the firm who accepts the subsidy
$w$	Welfare benefits received by the host country from stopping time $\tau_2$ to $\tau_1$
$y^{**}$	Investment trigger for optimal subsidised investment
$K(\Delta(y^{**}), \delta(y^{**}))$	Cost of the subsidy package inducing the investment to be made at $y^{**}$
$W(y_t t < \tau_2)$	Value of the welfare benefits of the subsidy prior to the stopping time $\tau_2$
$W(y_t t \geq \tau_2)$	Value of the welfare benefits after the stopping time $\tau_2$
$\tau_C$	Stopping time when the winning firm becomes known and makes the investment
$V(y_t t < \tau_C, Win)$	Value of the investment opportunity, conditional on it belonging to the winning firm
$V(y_t t < \tau_C, Lose)$	Value of the investment opportunity, conditional on it belonging to the losing firm
$W(y_t t < \tau_C, Win)$	Value of the welfare, conditional on it belonging to the winning country
$W(y_t t < \tau_C, Lose)$	Value of the welfare, conditional on it belonging to the losing country
$K(y^{**})$	Value of the subsidy package to induce the investment when $y^{**}$ is reached
$\Delta(y^{**})$	Value of the investment support to induce the investment when $y^{**}$ is reached
$\delta(y^{**})$	Value of the tax relief to induce the investment when $y^{**}$ is reached
$\Delta_i^P$	Investment support offered by the host country in the work by Pennings (2000)
$\delta_i^P$	Extra tax rate imposed by the host country in the work by Pennings (2000)

---

---

$y^P$	Optimal investment trigger when a self-financing subsidy package is provided in the work by Pennings (2000)
$\Delta^Y$	Investment support offered by the host country in the work by Yu <i>et al.</i> (2007)
$\delta^Y$	Extra tax rate imposed by the host country in the work by Yu <i>et al.</i> (2007)
$y^Y$	Optimal investment trigger in the work by Yu <i>et al.</i> (2007)
$W(y^{**})$	Value of the welfare benefit when investment is made at $y^{**}$
$y_C^*$	Optimal investment trigger of a competing firm
$F(y)$	Probability distribution of the optimal investment trigger of a competing firm
$h_F(y)$	Hazard rate that the investment will be made by a competing firm
$f(y)$	Probability density function of $F(y)$
$G(y)$	Probability that a competing country offers a subsidy at $y_t \leq y$
$\bar{y}_t$	‘All time high’ of the earning process up to and including time $t$
$G(y \bar{y}_t)$	Probability that the subsidy is offered by a competing country at $y_t \leq y$ given $\bar{y}_t$
$W(y_t t < \tau_2, \bar{y}_t)$	Value of the option to offer a subsidy at $y^{**}$
$g(y)$	Probability density function of $G(y)$
$h_G(y)$	Hazard rate that the subsidy will be offered by a competing country

---

# Chapter 3

## Mode of Entry

### 3.1 Introduction

When firms decide to engage in FDIs, the choice of entry mode is one of the fundamental issues that must be considered (Buckley and Casson, 1998). This chapter will focus on market entry mode, that is, how the FDIs should be organised and governed. Sharma and Erramilli defined entry mode as: A structural agreement that allows a firm to implement its product market strategy in a host country either by carrying out only the market operations (i.e. via export modes), or both production and marketing operations there by itself or in partnership with others (contractual modes, joint ventures, wholly owned operations).(2004, p.2)

We can also broadly categorise market entry modes into two types: equity modes, such as JVs, WOSs, and acquisitions, and non-equity modes, such as exporting, licensing, and franchising.

The mode of entry in the area of FDI is extensively studied, and many theories have been proposed to explain a firm's choice of entry mode. Among them, the transaction-cost theory

is the most fundamental and commonly used. The theory provides a cost-based view and suggests that firms choose certain entry modes to minimise transaction costs arising from entering and operating in a host country (Anderson and Gatignon, 1986; Hennart, 1989; Williamson, 1979, 1985). The OLI theory is another influential theory (Dunning, 1993). As suggested by its name, the OLI theory identifies three factors that affect a firm's choice of entry mode – ownership, location, and internalisation. Culture/cultural distance theory has also been used to account for the influences of culture/cultural distance on the choice of entry mode and to examine the effect of differences in the cultural backgrounds of partners in ventures. Institution theory emphasises the effects of the institutional aspects, such as rules, norms, and values, in the selection of the entry mode and operation in a foreign country. Other theories and constructs include control, internationalisation, risk, resource-based view, FDI, organisational capabilities, knowledge-based view, and uncertainty.<sup>1</sup>

In this thesis, it is assumed that the investment environment is highly uncertain and that the investment is irreversible. Under uncertainty and irreversibility, management flexibility should be considered valuable and carefully taken into account when evaluating the investment project and choosing an entry mode. Real options theory can be applied in this situation and offers a unique view. When choosing an entry mode, firms should not only consider the value of real options embedded already (e.g., the option to wait), they can also create real options to deal with the uncertainty through selecting a certain entry mode. The selection of an entry mode can be regarded as a means to deal with or even take advantage of market uncertainty. For example, international JVs (IJVs) are always considered to incorporate real options. By establishing an IJV, an MNE can create a foothold when market conditions are unfavourable and retain the opportunities to acquire or disinvest in the future. The MNE can acquire more equity stake from partners when market conditions improve or

---

<sup>1</sup>Canabal and White III (2008) provided a comprehensive overview.

sell equity stake to partners when market conditions deteriorate. This option limits the loss and retains the potential profits and thus is analogous to a call option.

There are also a few studies analysing the choice of entry mode from the real options perspective. Kogut (1991) qualitatively examined why JVs can be interpreted as options to expand and acquire a venture and analysed the factors that increase the likelihood of an acquisition through statistical investigations. Chi and McGuire (1996) used a two-stage binomial model to study the influences of transaction cost and strategic option on the valuation of a collaborative venture. They found that the option to acquire or sell out adds value to the JV when the partners have different views on the future value of the venture. Buckley and Casson (1998) conceptually identifies the real option of an IJV in the sense that a firm taking this mode has the option to acquire its partner's equity when market conditions are favourable, and disinvest when market conditions are unfavourable. Pennings and Sleuwaegen (2004) attempted to study timing and entry mode simultaneously. Following Dixit and Pindyck (1994), they derived the optimal trigger values of profits for setting up a WOS, a non-cooperative JV, and a cooperative JV. They found that the choice of entry modes depends on several factors, such as market uncertainty, tax differentials, cost advantage, institutional requirements, and degree of cooperation between partners. Li and Rugman (2007) used two-period binomial models to analyse an MNE's choices of investment location and market entry mode. They distinguished between the exogenous uncertainty and the endogenous uncertainty and suggested that both the magnitude and the type of uncertainty can influence the choice of entry mode. Chi and Seth (2009) employed a model combining real options theory and game-theoretical concepts to examine the factors that will influence the choice of entry mode. These factors include the parties' absorptive capacities, frictions in knowledge and asset markets and associated incentive problems, cost of switching from one

mode to another, and cost associated with jockeying for power among stakeholders. They used simulations to examine how these factors affect the choice of entry modes and derived a number of conditions for one factor to dominate another.

In this chapter, we study investment timing and choice of entry mode simultaneously and aim to provide decision rules for entry choice between a JV and WOS. We argue that investment timing and entry choice can be studied together because, from a firm's point of view, choosing a different entry mode may affect the value of the investment project and may further affect the optimal investment timing. From a host country's point of view, if it prefers the investment to be made at a certain point in time, the subsidy packages required to influence a firm's optimal investment timing are different when different entry modes are adopted by the firm. Therefore, the interplay between investment timing and choice of entry mode motivates us to study them simultaneously.

We focus on and compare two types of entry modes: a JV and WOS. Both of them are referred to as equity entry modes in the sense that they require higher levels of resource commitments and thus require higher levels of control. They are still different in several ways. As suggested by Li and Rugman (2007), these two types of entry modes are distinguishable from each other in the following aspects. First, they may require different initial costs to set up the investments. Li and Rugman (2007) suggested that it is reasonable to assume that a WOS requires higher initial investments than a JV. Second, they may be subject to different costs to exercise the options. Specifically, a WOS can expand its production capacity with no costs. A JV has to expand through acquiring its local partner's equity and may have to pay a certain amount of premium to its local partners. Last, they may differ in the ability to obtain information and reduce uncertainty. Since both types of entry modes are very commonly used in practice, the concern about which mode is better is universal. Empirical

evidence on this issue is quite mixed. Luo (1996) found that the WOS has significantly higher profitability than the JV for China. However, Pan and Chi (1999) found that JVs are more profitable.

It should be noted that different modes of entry have different implications for the benefits of the investment to the investing firm. Owning the investment outright means that the firm can exercise full control on the subsidiary. Sharing control in a JV means that some control is delegated to a local interest, which may be costly to the firm since it has to co-operate with its local partner. In the following analysis, we structure this problem around the control of output. We assume that, if the investing firm can exercise full control of a subsidiary, the production may be scaled up in good times and scaled back in lean times in order to maximise profits. In contrast, we assume that such down-scaling of output is not feasible if the firm enters into a JV agreement. There are also implications for the host country. A JV gives the host country a stake in an investment, which may be profitable and therefore may partially finance a subsidy, and the fact that output can be better controlled gives a stable welfare benefit. The optimal mode of entry for an unsubsidised investment is, therefore, not necessarily the same as the mode of entry for a subsidised investment.

There is much research on the choice between structuring an FDI investment as a WOS with full control and on structuring it as a JV that is, in part, locally controlled.<sup>2</sup> However, much less work has been done on the mode of entry in the context of investment subsidy, which forms another motivation for the following analysis. Is it cheaper to attract investments if the host country takes a stake in the firm? How does this arrangement affect the welfare benefits of the investment? These are the two issues addressed in this chapter. Additionally, we investigate the dynamic nature of subsidies, where the timing and magnitude of the optimal subsidy is analysed. The work is done in the context of FDI, but this problem

---

<sup>2</sup>See Canabal and White III (2008) for a review.

is more general, as it applies to any form of investment in which operational flexibility is an issue and in which an outside agent may have an interest in influencing the behaviour of the investing firm.

As mentioned in previous chapters, FDI subsidies can take various forms but can be broadly categorised into two types – those that provide investment support at the time of investment, for instance by offering land subsidies, cheap access to infrastructure, cheap financing, and support in the form of research and development and those that provide cheaper operating costs in the longer term, for instance a reduced corporate tax rate, tax holidays, and accelerated depreciation.<sup>3</sup> Our focus in this chapter is instead on whether it is optimal for the host country to offer a subsidy for an investment where the control right over output is given to the firm (a WOS) or to the country (a JV). We assume that the essential difference is that, with a WOS, the firm may scale back production under poor market conditions to maximise profits, but with a JV, there is less flexibility for the firm and the output will be kept at capacity even under poor market conditions to maximise the welfare effects of the investment to the host country.

We evaluate the investment given different entry modes and derive their respective investment thresholds. We compare the effects of different entry modes on the timing and the value of investment from the firm's perspective. From the country's perspective, we derive the optimal subsidy package given different entry modes and attempt to determine which mode dominates the other under different conditions.

This rest of this chapter is organised as follows. In Section 3.2, we set up the assumptions and models in which no subsidy is offered by the host country. We evaluate the investment

---

<sup>3</sup>Some literature investigates which form of subsidy is best (see e.g., Asano, 2010; Pennings, 2000, 2005; Yu *et al.*, 2007, among others) and other literature that investigates the welfare effects of subsidy. For an overview see Besley and Seabright (1999) and for recent contributions see Albornoz *et al.* (2009) and Chor (2009).



projects in which different entry modes are selected and derive the respective investment thresholds. We also derive the welfare of the host country when different entry modes are adopted. Last, we provide decision rules for the choice of entry mode between a JV and WOS. In Section 3.3, we extend the models to the case in which an investment subsidy is offered by the host country and derive the optimal investment subsidies for a JV and WOS. We also attempt to determine the optimal entry model through comparing a) the values of the investment projects when the investment triggers are set as identical and b) the investment triggers when the values of the investment projects are set as identical. Then, we introduce the knowledge transfer benefits and study their effect on the choice of entry mode. Section 3.4 presents some empirical implications, and Section 3.5 concludes the chapter.

## 3.2 Unsubsidised Investment

In this section, we consider the case in which no subsidy is offered by the host country. Consider a risk-neutral firm that has monopolistic access to invest in a project no matter whether in the form of a JV or WOS. The firm will operate in continuous time indexed by  $t \in [0, \infty)$ . The risk-free interest rate is known and constant at  $r > 0$  per unit of time.

To undertake the investment at time  $t$ , the firm has to incur an initial fixed investment cost,  $I$ , at that instant. We do not take into account personal and corporate taxes in this chapter since it will not alter our conclusions but would make the derivations more complex.

Suppose the investment in a production facility can produce  $q_t$  units of a good at a variable cost of  $\frac{v}{2}q_t$  and can be sold at price  $p_t$  at time  $t$ . The market price of the good,  $p_t$ , evolves over time according to a geometric Brownian motion:

$$dp_t = \mu p_t dt + \sigma p_t dB_t, \quad (3.1)$$

where  $\mu < r$  and  $\sigma > 0$  are constant and denote the drift and volatility of the process, respectively, and  $dB_t$  is the increment of a standard Brownian motion.<sup>4</sup> The Eq. (3.1) implies that the growth rate of  $p_t$  is normally distributed with mean,  $\mu$ , and variance,  $\sigma^2$ , per unit of time. Suppose the initial value of  $p_t$  at  $t = 0$  is  $p_0$ . We assume that  $p_0$  is sufficiently small such that the immediate investment is not optimal.

The decision rule is the same as stated in the previous analysis: when the market price  $p_t$  is large enough such that the investment project becomes sufficiently attractive, the firm finds it is optimal to undertake the investment project and give up the option value of waiting, which can be regarded as the opportunity cost. Hence, the focus of the analysis is to find a threshold value,  $p^* > p_0$ , such that the firm should invest at the first instant when  $p_t$  reaches  $p^*$  from below.<sup>5</sup> We refer to  $p^*$  as the optimal investment trigger and let  $T = \inf\{t > 0 : p_t = p^*\}$  be the first time that  $p_t$  reaches  $p^*$  from below, starting from  $t = 0$ .

We will study two types of entry mode in the following sections. The first entry mode is an investment structured as a JV between the foreign firm and the host country, in which the foreign firm owns  $\alpha$  per cent of the investment and the host country owns  $1 - \alpha$  per cent of the investment. The second entry mode is structured as a WOS, in which the foreign firm owns the enterprise outright and dictates both the timing of the investment and the output. As mentioned above, a JV is assumed to choose its optimal production level once the investment is made and stick to it thereafter since the host country wants the JV to maintain production even in bad times to guarantee employment. A WOS is supposed to have full control over its production and can scale up and back its production freely according to market conditions. In the following analysis, variables with subscripts 'J' and 'S' correspond to JVs and WOSs, respectively.

---

<sup>4</sup>The condition  $\mu < r$  is needed to ensure the expected present value of the investment project is finite.

<sup>5</sup>See McDonald and Siegel (1986) and Dixit and Pindyck (1994).

### 3.2.1 Joint Venture

We first consider the case of a JV. A JV is an agreement to share the profit flow and the investment cost of the enterprise between the foreign firm and host country. The foreign firm owns  $\alpha \in (0, 0.5)$  of the enterprise, while the host country owns  $1 - \alpha$ . We assume that  $\alpha$  is exogenously decided (for example because the host country does not permit a foreign firm to own more than half of the shares of a JV) but large enough to give the foreign firm veto rights on the timing of the investment, and  $1 - \alpha$  is large enough to give the host country veto rights on the output of the investment. In other words, it is the foreign firm who decides when to invest. Once the investment is made, the JV has to commit to a certain level of production. The profit flow is given by  $q_t (p_t - \frac{v}{2} q_t)$ . When the production flow is kept constant at capacity  $q_t = q$  indefinitely, the value of all discounted future profits for a JV is given by:

$$V_J(p_t|q) = \mathbb{E} \left( \int_t^\infty q \left( p_s - \frac{v}{2} q \right) e^{-r(s-t)} ds \middle| p_t \right) = \frac{qp_t}{r - \mu} - \frac{vq^2}{2r}, \quad (3.2)$$

when the investment is made at  $p_t$ .<sup>6</sup>

Since the value of the investment project and the investment cost will be shared between the foreign firm and the host country, the value for the foreign firm is then  $\alpha V_J(p_t|q)$  and the cost is  $\alpha I_J$  when  $I_J$  denotes the cost of setting up the JV. Similarly, the value for the host country is  $(1 - \alpha) V_J(p_t|q)$ , and the cost is  $(1 - \alpha) I_J$ .

The investment opportunity is worth  $\alpha V_J(p_t|q) - \alpha I_J$  at the time of investment. The

---

<sup>6</sup>It should be noted that we neglect the sequential option to acquire the equity stake from the local partner that a JV is usually thought to hold. As pointed out by Li and Rugman (2007), these options to acquire and expand ventures require different costs to be exercised. A firm may need to pay a premium (or discount) to acquire equity stake from its local partner for switching from a JV to a WOS. The exercise cost can be so high that the option value of acquiring or selling out can be totally offset.

optimal investment trigger can be obtained as:

$$p_J^* = \frac{\lambda}{\lambda - 1}(r - \mu) \left( \frac{vq}{2r} + \frac{I_J}{q} \right), \quad (3.3)$$

where  $\lambda = \left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right) + \sqrt{\left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right)^2 + \frac{2r}{\sigma^2}}$  (see e.g., Dixit and Pindyck, 1994).<sup>7</sup> The optimal capacity can be found by maximising the value of all discounted future profits when the investment is made at  $p_J^*$ ,  $V_J(p_J^*|q)$ , which yields  $q^* = \frac{p_J^*}{v} \frac{r}{r-\mu}$ . Substituting  $q^*$  back into  $V_J(p_J^*|q)$ , we can find that  $V_J(p_J^*|q^*) = \frac{r}{(r-\mu)^2} \frac{(p_J^*)^2}{2v}$ .

Using value-matching and smooth-pasting conditions (Dixit and Pindyck, 1994), we can also find the following:

**Proposition 3.1** *Under all of the above assumptions, the value of the investment opportunity for a JV can be expressed as:*

$$\alpha (V_J(p_t|p_J^*) - I_J) = \alpha \frac{I_J}{\gamma - 1} \left( \frac{p_t}{p_J^*} \right)^{2\gamma}, \quad (3.4)$$

where  $\gamma$  is the positive root of the quadratic equation  $2\sigma^2\gamma(\gamma - 1) + (2\mu + \sigma^2)\gamma - r = 0$ . The optimal investment trigger  $p_J^*$  for a JV satisfies:

$$p_J^* = \sqrt{\frac{2v\gamma}{\gamma - 1} \frac{(r - \mu)^2}{r} I_J}. \quad (3.5)$$

It can be shown that  $\gamma = \lambda/2$ . This expression assumes that  $\gamma > 1$  or equivalently,  $\lambda > 2$ .

It shows that the expected payoff at the time of investment for the foreign firm is

---

<sup>7</sup>Note that the optimal investment trigger,  $p_J^*$ , is not affected by the equity share  $\alpha$  since, in our model, the value of the investment and the cost are shared in the same proportion between the foreign firm and the host country, which is different from the analysis by Pennings and Sleuwaegen (2004) who assumed that the foreign firm has to be compensated for its input of knowledge and technology.

$$\alpha V_J(p_J^*|q^*) = \alpha \frac{\gamma I_J}{\gamma - 1}.$$

### 3.2.2 Wholly-Owned Subsidiary

Next, we consider the case of a WOS. The foreign firm can dictate both the timing of investment and the output when it invests in a WOS, where the investment cost is denoted by  $I_S$ . When the investment is made, the profit flow is  $q_t (p_t - \frac{v}{2} q_t)$ . Suppose the firm can adjust its production level  $q_t$  without cost, it can then maximise the profit flow with respect to  $q_t$  point by point. This yields an optimal production  $q_t^* = \frac{p_t}{v}$ . The maximised profit flow is then equal to  $\frac{p_t^2}{2v}$ , which depends on the evolution of  $p_t^2$ . Since  $p_t$  follows a geometric Brownian motion, using Ito's lemma, we find that  $dp_t^2 = (2\mu + \sigma^2) p_t^2 dt + 2\sigma p_t^2 dB_t$ , which indicates  $p_t^2$  also follows a geometric Brownian motion with drift  $2\mu + \sigma^2$  and diffusion  $2\sigma$ . We assume that  $2\mu + \sigma^2 < r$ .<sup>8</sup> The value of the future discounted profits is given by:

$$V_S(p_t|q_t^*) = \mathbb{E} \left( \int_t^\infty \frac{p_s^2}{2v} e^{-r(s-t)} ds \middle| p_t \right) = \frac{p_t^2}{2v(r - 2\mu - \sigma^2)}. \quad (3.6)$$

Using the above approach (Dixit and Pindyck, 1994), we can find the following:

**Proposition 3.2** *Under all of the above assumptions, the value of the investment opportunity for a WOS is:*

$$V_S(p_t|p_S^*) - I_S = \frac{I_S}{\gamma - 1} \left( \frac{p_t}{p_S^*} \right)^{2\gamma}, \quad (3.7)$$

where  $\gamma$  has been defined above. The optimal investment trigger  $p_S^*$  for a WOS satisfies:

$$p_S^* = \sqrt{\frac{2v\gamma}{\gamma - 1} (r - 2\mu - \sigma^2) I_S}. \quad (3.8)$$

---

<sup>8</sup>This assumption holds when the growth rate and the volatility of product prices are sufficiently small. A natural growth rate for product prices is inflation, which is typically lower than the discount rate, and it is argued (see e.g., Miao, 2005) that in industry equilibrium, the product prices are much less volatile than, for instance asset prices.

*This expression also assumes that  $r > (2\mu + \sigma^2)$  and  $\gamma > 1$  or  $\lambda > 2$ , equivalently.*

Proposition 3.2 shows that the expected payoff at the time of investment is  $V_S(p_S^*|q_t^*) = \frac{\gamma I_S}{\gamma-1}$ .

If both modes are to have the same optimal investment trigger (i.e.,  $p_J^* = p_S^*$ ), we find that:

$$I_J = I_S \frac{r(r - 2\mu - \sigma^2)}{(r - \mu)^2}. \quad (3.9)$$

Since  $\frac{(r-\mu)^2}{r} > (r - 2\mu - \sigma^2)$ , we find the ratio  $\frac{r(r-2\mu-\sigma^2)}{(r-\mu)^2}$  is always less than one, which implies that if we want both modes of entry to have the same investment timing, the investment cost for a JV,  $I_J$ , must be less than the investment cost for a WOS,  $I_S$ , since the flexibility to vary output freely is valuable. This requirement is consistent with the findings of Li and Rugman (2007) who stated that it is reasonable to assume that a WOS requires higher initial investments than a JV since a JV may have access to some unique local resources. The incremental investment  $I_S - I_J$  can be interpreted as the investment in technology that allows the firm to scale up or down production with no further costs, whereas  $I_J$  is the investment in fixed capacity  $q = \frac{p_J^*}{v} \frac{r}{r-\mu}$ . Note that, since  $I_S > I_J$ ,  $V_S(p_S^*|q_t^*) = \frac{\gamma I_S}{\gamma-1}$  will always be greater than  $V_J(p_J^*|q^*) = \frac{\gamma I_J}{\gamma-1}$  at the time of investment, implying that an investment project in the form of a WOS will have a higher value. Thus, a WOS will be preferred by the foreign firm.

Another natural basis for comparison between the two entry modes is that we make the expected NPV of the investment project the same at the time of investment, regardless of the decision to structure the investment as a JV or WOS, which implies that  $V_J(p_J^*|q^*) = \frac{\gamma I_J}{\gamma-1}$  has the same as  $V_S(p_S^*|q_t^*) = \frac{\gamma I_S}{\gamma-1}$ , implying  $I_J = I_S$ .

If  $I_J$  and  $I_S$  have the same value of  $I$ , it can be shown that  $p_J^* > p_S^*$  since

$$p_J^* = \sqrt{\frac{2v\gamma}{\gamma-1} \frac{(r-\mu)^2}{r} I} = \sqrt{\frac{2v\gamma}{\gamma-1} (r-2\mu + \frac{\mu^2}{r}) I}$$

, and it is obvious that  $(r-2\mu + \frac{\mu^2}{r}) > (r-2\mu - \sigma^2)$ . It implies that, other things being equal, a WOS that has more flexibility will have a lower investment trigger and make the investment sooner. Thus, a WOS will have a higher discounted value of investment project at time 0. Since  $p_J^* > p_S^*$ ,  $V_S(p_t|p_S^*)$  will always be greater than  $V_J(p_t|p_J^*)$  at any given  $p_t$ , indicating that, at any given point in time prior to the investment, the value of the investment opportunity for a WOS will be higher. This does make sense since, with all other things being equal, the firm with full control over production has extra 'flexibility'. Therefore, a WOS will again be preferred by the firm.

In summary, we find that a WOS will always be preferred by the firm from a commercial point of view to undertake an investment when the investment environment is uncertain and the investment is irreversible but flexible. The reason is that a WOS can offer the firm full control over its production and this 'flexibility' is valuable.

### 3.2.3 Welfare

In this section, we consider the welfare benefits for the host country. The host country could obtain welfare from two sources: the output  $q_t$ , which indicates the level of economic activity of the enterprise, and the commercial value of an ownership stake when a JV is established. We assume that the output-related welfare can be measured as a constant  $w$  per unit of output. If an enterprise is established (i.e., the investment is made) at time  $t$  in the form of

a JV producing output  $q$ , the welfare can be expressed as:

$$W_J(p_t|q) = \int_t^\infty e^{-r(s-t)} w q ds + (1 - \alpha) (V(p_t|q) - I_J) = \frac{wq}{r} + (1 - \alpha) \left( \frac{qp_t}{r - \mu} - \frac{vq^2}{2r} - I_J \right). \quad (3.10)$$

If a JV produces the optimal output  $q^* = \frac{p_t}{v} \frac{r}{r - \mu}$ , we can find that:

$$W_J(p_t|q^*) = \frac{w}{v} \frac{p_t}{r - \mu} + (1 - \alpha) \left( \frac{1}{2v} \frac{r}{(r - \mu)^2} p_t^2 - I_J \right). \quad (3.11)$$

Substituting  $p_J^* = \sqrt{\frac{\gamma}{\gamma - 1} \frac{(r - \mu)^2}{r} 2v I_J}$  into the above equation, then we obtain:

$$W_J(p_t|q^*) = \frac{w}{v} \frac{p_t}{r - \mu} + (1 - \alpha) \left( \frac{\gamma I_J}{\gamma - 1} \left( \frac{p_t}{p_J^*} \right)^2 - I_J \right). \quad (3.12)$$

If an enterprise is established at time  $t$  in the form of a WOS producing the optimal output  $q_t^* = \frac{p_t}{v}$ , the welfare is

$$W_S(p_t|q_t^*) = \int_t^\infty w q_t^* e^{-r(s-t)} ds = \frac{w}{v} \frac{p_t}{r - \mu}. \quad (3.13)$$

For a JV, if we evaluate the welfare at the optimal investment trigger derived above,  $p_J^*$  (given in Eq. (3.5)), we find the welfare function equals:

$$W_J(p_J^*|q^*) = \frac{w}{v} \frac{p_J^*}{r - \mu} + (1 - \alpha) \frac{I_J}{\gamma - 1}. \quad (3.14)$$

For a WOS, if we evaluate welfare at the investment trigger,  $p_S^*$  (given in Eq. (3.8)), we find the welfare function equals:

$$W_S(p_S^*|q_t^*) = \frac{w}{v} \frac{p_S^*}{r - \mu}. \quad (3.15)$$



It suggests that if we make the timing of investment for both entry modes the same, which implies that  $p_J^* = p_S^*$ , the host country will gain more welfare benefits when a JV is established. If we equalise the welfare benefits for both entry modes, we can find that  $p_S > p_J$ , indicating that the investment in the form of a JV will be made sooner. Thus, at time 0, the discounted value of the investment in the form of a JV will be higher. It seems that a JV will always be preferred by the host country from the social welfare point of view.

### 3.2.4 Optimal Unsubsidised Investment

We now analyse the optimal decision making for an unsubsidised investment problem, and find the following rule.

**Proposition 3.3** *Suppose we consider two cases, Case 1 where the investment triggers are identical, so that  $p_J^* = p_S^*$  and the timing decision would be the same for a JV and WOS for the firm, and Case 2 where the NPVs of the investments are identical  $\frac{qp_J^*}{r-\mu} - \frac{vq^2}{2r} - I_J = \frac{p_S^2}{2v(r-2\mu-\sigma^2)} - I_S$  so that the surplus from investment is the same at the time the investment is made. Then, we find:*

- (1) *In Case 1, the firm prefers a WOS, and the host country prefers a JV.*
- (2) *In Case 2, the firm prefers a WOS, and the host country may prefer either, depending on model parameters.*

A WOS would, therefore, always be preferred to a JV by the firm from a commercial point of view. The reason for this is that the firm would either achieve a higher NPV at the investment point or would achieve the same NPV at an earlier date with a WOS. The latter point is often not obvious in static models where timing is not modelled. The welfare effect is always greater with a JV. This is because the optimal capacity under a JV is calibrated

such that the welfare effect of output is the same for both a WOS and JV, but the host country additionally has a commercial stake in the investment, which has positive value.

### 3.3 Subsidised Investment

In this section, we analyse the case in which the host country intends to lower the investment trigger level and speed up the investment by providing a subsidy package.

#### 3.3.1 Investment Subsidy

First, we analyse the case when the investment can be organised either in the form of a JV or in the form of a WOS. However, the firm cannot choose between them now or later.

We know from Chapter 2 that the optimal investment subsidy package must compensate the firm for the difference between the value of the investment opportunity, which is the firm's opportunity cost, and the value of the investment at an earlier time point. Suppose the subsidy package is denoted by  $K(p_t)$ , where  $p_t$  can be regarded as the host country's desired investment trigger. If  $p_t$  is also the optimal investment trigger for the firm in the sense that the firm decides to invest when the state variable first reaches  $p_t$  from below, some value-matching and smooth-pasting conditions must be met and the value of the subsidy package can be derived (Dixit and Pindyck, 1994).

For a JV, the foreign firm decides when to invest and set up the venture. The value of the optimal subsidy package should be  $\alpha K_J(p_t)$  and can be expressed as follows:

$$\alpha K_J(p_t) = \alpha \left( \frac{I_J}{\gamma - 1} \left( \frac{p_t}{p_J^*} \right)^{2\gamma} + I_J - \frac{\gamma I_J}{\gamma - 1} \left( \frac{p_t}{p_J^*} \right)^2 \right). \quad (3.16)$$

The equity share of the foreign firm,  $\alpha$ , comes into play since the foreign firm shares future

profit and investment cost with the host country and pursues maximisation of its own profit.

Similar results can also be obtained for a WOS. The value of the subsidy package to lower the optimal invest trigger to  $p_t$  takes the value:

$$K_S(p_t) = \frac{I_S}{\gamma - 1} \left( \frac{p_t}{p_S^*} \right)^{2\gamma} + I_S - \left( \frac{p_t}{p_S^*} \right)^2 \frac{\gamma}{(\gamma - 1)} I_S. \quad (3.17)$$

As can be seen from Eqs. (3.16) and (3.17), when investment triggers are kept unchanged (i.e.,  $p_t = p_J^*$  or  $p_t = p_S^*$ ), the value of the subsidy packages are equal to zero, indicating that the host country needs to pay nothing to let the investment take place naturally, when  $p_t$  approaches zero,  $K_J(p_t)$  and  $K_S(p_t)$  approaches  $I_J$  and  $I_S$ , respectively.

When the host country considers subsidising the firm, it faces a trade-off between the incremental welfare, which is the difference between the welfare benefits from the subsidised investment and the unsubsidised investment and the cost of providing the subsidy package.

For a JV, the incremental welfare can be expressed as:

$$\Delta W_J(p_t) = W_J(p_t|q^*) - W_J(p_J^*|q^*) \left( \frac{p_t}{p_J^*} \right)^{2\gamma}, \quad (3.18)$$

where  $W_J(p_t|q^*)$  and  $W_J(p_J^*|q^*)$  are given in Eqs. (3.12) and (3.14), respectively. Additionally,  $\left( \frac{p_t}{p_J^*} \right)^{2\gamma}$  denotes the discount factor because  $W_J(p_J^*|q^*)$  is evaluated at the time when  $p_J^*$  is first reached and because we have to discount it to the time of  $p_t$  so that Eq. (3.18) makes sense.<sup>9</sup>

---

<sup>9</sup>See Harrison (1985) for the derivation of the discount factor.

The incremental welfare minus the cost of the subsidy is then given by:

$$\Delta W_J(p_t) - \alpha K_J(p_t) = \frac{w}{v(r - \mu)} \left( p_t - p_J^* \left( \frac{p_t}{p_J^*} \right)^{2\gamma} \right) + \left( \frac{\gamma I_J}{\gamma - 1} \left( \frac{p_t}{p_J^*} \right)^2 - I_J \right) - \frac{I_J}{\gamma - 1} \left( \frac{p_t}{p_J^*} \right)^{2\gamma}. \quad (3.19)$$

Please note that the parameter  $\alpha$  does not enter the right-hand side of this expression, so it is immaterial whether the firm holds a large commercial stake in the JV and pays a small subsidy or whether it holds a small commercial stake and pays a large subsidy.

Similarly, we can find that the incremental welfare for a WOS is given as follows:

$$\Delta W_S(p_t) = W_S(p_t|q_t^*) - W_S(p_S^*|q_t^*) \left( \frac{p_t}{p_S^*} \right)^{2\gamma}, \quad (3.20)$$

where  $W_S(p_t|q_t^*)$  and  $W_S(p_S^*|q_t^*)$  are given in Eqs. (3.13) and (3.15), respectively. Moreover,  $\left( \frac{p_t}{p_S^*} \right)^{2\gamma}$  denotes the discount factor.

The incremental welfare minus the cost of the subsidy for a WOS is given by:

$$\Delta W_S(p_t) - K_S(p_t) = \frac{w}{v(r - \mu)} \left( p_t - p_S^* \left( \frac{p_t}{p_S^*} \right)^{2\gamma} \right) + \left( \frac{\gamma I_S}{\gamma - 1} \left( \frac{p_t}{p_S^*} \right)^2 - I_S \right) - \frac{I_S}{\gamma - 1} \left( \frac{p_t}{p_S^*} \right)^{2\gamma}. \quad (3.21)$$

If we want to find out which mode of entry is more attractive to the host country, we need to compare  $\Delta W_J(p_t) - \alpha K_J(p_t)$  with  $\Delta W_S(p_t) - K_S(p_t)$ .

We have studied the case in which the firm cannot choose between a JV and a WOS. Next, we analyse the case when the foreign firm has the option to choose between the two types of entry mode.

As stated in Section 2, a WOS would always be preferred over a JV from the foreign firm's point of view. Now, if the host country wants to lower the optimal investment trigger and

speed up the investment through providing a subsidy package, the optimal subsidy package must be structured in such a way that it compensates the firm for the difference between the firm's best outside option, which we know from the preceding section is equal to the value of the investment in the form of a WOS, and the value of the investment made at the time stipulated in the subsidy contract. For instance, if the firm is offered a subsidy for a JV at a time where the product price  $p^{**}$ , which is lower than the unsubsidised investment trigger for a WOS,  $p^{**} < p_S^*$ , then the subsidy must compensate for the difference between the value of the opportunity to invest as a WOS minus the NPV of the JV. The value of the opportunity to invest in a WOS has been worked out in Section 2 as  $V_S(p_t|p_S^*) - I_S = \frac{I_S}{\gamma-1}(\frac{p_t}{p_S^*})^{2\gamma}$ , which is the value of the outside option for the firm at a time when the product market price is  $p_t < p_S^*$ .

The NPV for the firm of a JV where the subsidised investment is made at a time when the price is  $p_t$  is  $\alpha \left( \frac{p_t q}{r-\mu} - \frac{vq^2}{2r} - I_J \right)$ . Using the optimal capacity decision  $q = \frac{p_t}{v} \frac{r}{r-\mu}$ , we find the NPV  $\alpha \left( \frac{1}{2v} \frac{r}{(r-\mu)^2} p_t^2 - I_J \right)$ . Given that  $p_J^* = \sqrt{\frac{\gamma}{\gamma-1} \frac{(r-\mu)^2}{r} 2v I_J}$ , the NPV is  $\alpha \left( \frac{\gamma I_J}{\gamma-1} (\frac{p_t}{p_J^*})^2 - I_J \right)$ .

The NPV for the firm of a WOS when the subsidised investment is made at a time the price is  $p_t$  is  $\left( \frac{1}{2v} \frac{p_t^2}{(r-2\mu-\sigma^2)} - I_S \right)$ . Given that  $p_S^* = \sqrt{\frac{\gamma}{\gamma-1} (r-2\mu-\sigma^2) 2v I_S}$ , the NPV is  $\left( \frac{\gamma I_S}{\gamma-1} (\frac{p_t}{p_S^*})^2 - I_S \right)$ .

We find the following result.

**Proposition 3.4** *The optimal subsidy for a JV with ownership stake  $\alpha$  for the foreign firm is:*

$$K_J(p_t) = \frac{I_S}{\gamma-1} (\frac{p_t}{p_S^*})^{2\gamma} - \alpha \left( \frac{\gamma I_J}{\gamma-1} (\frac{p_t}{p_J^*})^2 - I_J \right), \quad (3.22)$$

*and the optimal subsidy for a WOS is:*

$$K_S(p_t) = \frac{I_S}{\gamma-1} (\frac{p_t}{p_S^*})^{2\gamma} - \left( \frac{\gamma I_S}{\gamma-1} (\frac{p_t}{p_S^*})^2 - I_S \right). \quad (3.23)$$

Comparing Eqs. (3.23) with (3.17), we find that the value of the subsidy package needed to lower the optimal invest trigger to  $p_t$  remains the same for a WOS. Comparing Eqs. (3.22) with (3.16), we find that, when the foreign firm has the option to choose between the two types of entry mode, the host country has to provide additional subsidy for a JV.

Therefore, the welfare for the host country of subsidising an investment via a JV is the incremental welfare arising from a subsidy at the price  $p_t$  minus the cost of the optimal subsidy package  $K_J(p_t)$ . To work out the incremental welfare, we need to consider the welfare to the host country when no subsidy is offered and when there is a subsidy offered.

When there is no subsidy offered and the firm has the option to choose between the two entry modes, the firm will always choose a WOS, as we have mentioned above. The welfare to the host country of an unsubsidised investment is given by  $W_S(p_S^*|q_t^*) = \frac{w}{v} \frac{p_S^*}{r-\mu}$ . Since there is no subsidy offered, the investment will be made when the optimal investment trigger  $p_S^*$  is reached, and the host country can obtain welfare flow from then on. Further,  $W_S(p_S^*|q_t^*)$  is actually the value of all discounted future welfare at the time of investment,  $T_S = \operatorname{argmin}_t \{p_t = p_S^*\}$ .

When the host country provides subsidies to lower the optimal investment trigger to  $p_t$  and the investment is in the form of a JV, the welfare to the host country of a subsidised investment via a JV is given by Eq. (3.12) as  $\frac{w}{v} \frac{p_t}{r-\mu} + (1-\alpha) \left( \frac{\gamma I_J}{\gamma-1} \left( \frac{p_t}{p_S^*} \right)^2 - I_J \right)$  at time  $t$ . Since the optimal investment trigger is lower and the investment is sped up,  $t < T_S$ .

Therefore, when we calculate the incremental welfare, we need to discount  $W_S(p_S^*|q_t^*)$  to time  $t$ . The discount factor  $E[\exp(-r(T_S - t))]$ , with  $T_S = \operatorname{argmin}_t \{p_t = p_S^*\}$ , equals  $\left( \frac{p_t}{p_S^*} \right)^{2\gamma}$  (see Harrison, 1985). Then, the incremental welfare of a subsidised investment via a JV

minus the optimal subsidy can be written as:

$$\begin{aligned} & \frac{w}{v} \frac{p_t}{r - \mu} + (1 - \alpha) \left( \frac{\gamma I_J}{\gamma - 1} \left( \frac{p_t}{p_J^*} \right)^2 - I_J \right) - \frac{w}{v} \frac{p_S^*}{r - \mu} \left( \frac{p_t}{p_S^*} \right)^{2\gamma} - K_J(p_t) \\ &= \frac{w}{v(r - \mu)} \left( p_t - p_S^* \left( \frac{p_t}{p_S^*} \right)^{2\gamma} \right) + \left( \frac{\gamma I_J}{\gamma - 1} \left( \frac{p_t}{p_J^*} \right)^2 - I_J \right) - \frac{I_S}{\gamma - 1} \left( \frac{p_t}{p_S^*} \right)^{2\gamma}. \end{aligned} \quad (3.24)$$

We notice that the parameter  $\alpha$  cancels out and does not enter Eq. (3.24), so it is immaterial whether the firm holds a large commercial stake in the JV and pays a small subsidy or whether it holds a small commercial stake and pays a large subsidy.

The welfare to the host country of a subsidised investment via a WOS is given by Eq. (3.13) as  $\frac{w}{v} \frac{p_t}{r - \mu}$ .

Therefore, similarly to the expression for the JV, the incremental welfare of a subsidised investment via a WOS minus the optimal subsidy can be written as:

$$\begin{aligned} & \frac{w}{v} \frac{p_t}{r - \mu} - \frac{w}{v} \frac{p_S^*}{r - \mu} \left( \frac{p_t}{p_S^*} \right)^{2\gamma} - K_S(p_t) \\ &= \frac{w}{v(r - \mu)} \left( p_t - p_S^* \left( \frac{p_t}{p_S^*} \right)^{2\gamma} \right) + \left( \frac{\gamma I_S}{\gamma - 1} \left( \frac{p_t}{p_S^*} \right)^2 - I_S \right) - \frac{I_S}{\gamma - 1} \left( \frac{p_t}{p_S^*} \right)^{2\gamma}. \end{aligned} \quad (3.25)$$

Then, we find the following result.

**Proposition 3.5** *The optimal subsidy trigger for a JV is given by:*

$$p_J^{**} = \left( p_J^{*2} + \left( w \frac{r - \mu}{r} \frac{\lambda - 1}{\lambda - 2} \right)^2 \right)^{\frac{1}{2}} - w \frac{r - \mu}{r} \frac{\lambda - 1}{\lambda - 2} < p_J^*. \quad (3.26)$$

*The optimal subsidy trigger for a WOS is given by:*

$$p_S^{**} = \left( p_S^{*2} + \left( w \frac{r - 2\mu - \sigma^2}{r - \mu} \frac{\lambda - 1}{\lambda - 2} \right)^2 \right)^{\frac{1}{2}} - w \frac{r - 2\mu - \sigma^2}{r - \mu} \frac{\lambda - 1}{\lambda - 2} < p_S^*. \quad (3.27)$$

The proof of Proposition 3.5 is in Appendix 3.6.

### 3.3.2 Optimal Mode of Entry

In this section, we will investigate the optimal mode of entry. We analyse two situations: a) when the firm cannot choose between a JV and a WOS and b) when the firm has the option to choose between the two entry modes and always prefer a WOS.

When the firm cannot choose between a JV and WOS, we compare  $(\Delta W_J(p_t) - \alpha K_J(p_t))$  and  $(\Delta W_S(p_t) - K_S(p_t))$ , which have been defined above under two cases.

First, we consider the situation when investments via both entry modes have the same optimal investment trigger (i.e.,  $p_J^* = p_S^*$ ). As mentioned above, when  $p_J^* = p_S^*$ ,  $I_J < I_S$ .

When  $p_J^* = p_S^*$ , we find that:

$$\begin{aligned} & (\Delta W_J(p_t) - \alpha K_J(p_t)) - (\Delta W_S(p_t) - K_S(p_t)) \\ &= \left( \frac{\gamma}{\gamma - 1} \left( \frac{p_t}{p_J^*} \right)^2 - 1 - \frac{1}{\gamma - 1} \left( \frac{p_t}{p_J^*} \right)^{2\gamma} \right) (I_J - I_S). \end{aligned} \quad (3.28)$$

Note that the second term of the expression,  $(I_J - I_S)$ , is negative. Thus, we focus on the first term of the expression. If we let  $x = \frac{p_t}{p_J^*} = \frac{p_t}{p_S^*}$ , since  $0 < p_t \leq p_J^* = p_S^*$ ,  $0 < x \leq 1$ .

Let

$$f(x) = \frac{\gamma}{\gamma - 1} x^2 - 1 - \frac{1}{\gamma - 1} x^{2\gamma}. \quad (3.29)$$

Then, the first derivative of  $f(x)$  with respect to  $x$  is:

$$f'(x) = \frac{2\gamma}{\gamma - 1} (x - x^{2\gamma-1}). \quad (3.30)$$

Since  $\gamma > 1$ ,  $2\gamma - 1 > 1$ . Since  $x < 1$ ,  $x^{2\gamma-1} < x$  or  $x - x^{2\gamma-1} > 0$ . Therefore,  $f(x)$  is an



increasing function. Since  $f(x) = 0$  when  $x = 1$ , we find that the maximum value of  $f(x)$  is zero. When  $0 < x < 1$ ,  $f(x)$  will always be less than zero.

Because the first term of Eq. (3.28) is also less than or equal to zero, we find that  $(\Delta W_J(p_t) - \alpha K_J(p_t)) - (\Delta W_S(p_t) - K_S(p_t))$  will be greater than or equal to zero, indicating that the incremental welfare subtracting the cost of subsidy will always be higher for a JV. Thus, in this situation, a JV will be more attractive than a WOS to the host country.

Second, we consider the situation in which the expected NPVs of the investment projects are the same at their respective times of investment for both entry modes (i.e.,  $I_J = I_S$ ). As mentioned above, when  $I_J = I_S$ ,  $p_J^* > p_S^*$ .

In this situation, we can find that:

$$\begin{aligned}
 & (\Delta W_J(p_t) - \alpha K_J(p_t)) - (\Delta W_S(p_t) - K_S(p_t)) \\
 &= -\frac{wp_t}{v(r-\mu)} \left(\frac{p_t}{p_J^*}\right)^{2\gamma-1} + \frac{\gamma I_J}{\gamma-1} \left(\frac{p_t}{p_J^*}\right)^2 - \frac{I_J}{\gamma-1} \left(\frac{p_t}{p_J^*}\right)^{2\gamma} \\
 & - \left( -\frac{wp_t}{v(r-\mu)} \left(\frac{p_t}{p_S^*}\right)^{2\gamma-1} + \frac{\gamma I_S}{\gamma-1} \left(\frac{p_t}{p_S^*}\right)^2 - \frac{I_S}{\gamma-1} \left(\frac{p_t}{p_S^*}\right)^{2\gamma} \right).
 \end{aligned} \tag{3.31}$$

Let  $g(y) = -\frac{wp_t}{v(r-\mu)}y^{2\gamma-1} + \frac{\gamma I_J}{\gamma-1}y^2 - \frac{I_J}{\gamma-1}y^{2\gamma}$ , and let  $y_1 = \frac{p_t}{p_J^*}$  and  $y_2 = \frac{p_t}{p_S^*}$ . Then, the expression of  $[(\Delta W_J(p_t) - \alpha K_J(p_t)) - (\Delta W_S(p_t) - K_S(p_t))] |_{I_J=I_S}$  becomes  $g(y_1) - g(y_2)$ . Note that  $0 < p_t \leq p_S^* < p_J^*$ , so  $0 < y_1 < y_2 \leq 1$ . The first derivative of  $g(y)$  with respect to  $y$  is:

$$g'(y) = -\frac{(2\gamma-1)wp_t}{v(r-\mu)}y^{2\gamma-2} + \frac{2\gamma I_J}{\gamma-1}y - \frac{2\gamma I_J}{\gamma-1}y^{2\gamma-1}. \tag{3.32}$$

In this case, the value of  $g'(y)$  depends on the parameter values. If  $g'(y) > 0$ ,  $g(y)$  is an increasing function. Since  $y_1 < y_2$ ,  $g(y_1) < g(y_2)$ . Then,  $g(y_1) - g(y_2)$  is negative, and so is  $[(\Delta W_J(p_t) - \alpha K_J(p_t)) - (\Delta W_S(p_t) - K_S(p_t))] |_{I_J=I_S}$ , implying that the incremental welfare

subtracting the cost of subsidy for a WOS will be higher. Thus, a WOS will be more attractive to the host country. When  $g'(y) < 0$ , the result will be reversed. When  $g'(y) = 0$ , the host country will be indifferent to the two types of entry modes.

Until now, we have studied the situation in which the host country offers subsidy packages and when the firm cannot choose between a JV and WOS. We find that when investments via both entry modes have the same investment trigger, a JV will be more attractive to the host country. When the expected present values of the investment projects are the same, the host country may prefer either mode depending on model parameters.

Second, we consider the situation in which the firm has the option to choose between the two entry modes and always prefer a WOS. The first issue is which of the subsidy trigger points in Proposition 3.5 is the smallest. If we start from a situation in which the unsubsidised investment triggers are identical (i.e., that  $p_J^* = p_S^*$ ), then we find that  $p_J^{**} < p_S^{**}$ . Note that this does not necessarily mean the host country will choose the JV as the optimal mode of entry since the option to delay the subsidy and offer the firm the option to invest in a WOS may yield even greater welfare. Therefore, the optimal mode of entry is not directly associated with the lowest subsidy trigger point.

As stated in Eq. (3.9), when  $p_J = p_S$ ,  $I_J = I_S \frac{r(r-2\mu-\sigma^2)}{(r-\mu)^2}$ . Since the ratio  $\frac{r(r-2\mu-\sigma^2)}{(r-\mu)^2}$  is less than one,  $I_J < I_S$ . The difference between the incremental welfare of a subsidised investment minus the optimal subsidy for a JV and for a WOS is given by difference between Eq. (3.24) and Eq. (3.25), which is:

$$\left( \frac{\gamma}{\gamma-1} \left( \frac{p_t}{p_S^*} \right)^2 - 1 \right) (I_J - I_S). \quad (3.33)$$

From Eq. (3.8), we obtain  $p_S^{*2} = \frac{2v\gamma}{\gamma-1}(r-2\mu-\sigma^2)I_S$ . Substituting  $p_S^{*2}$  and  $I_J$  into Eq. (3.33), it can be simplified to:

$$\left( \frac{p_t^2}{2v} - (r - 2\mu - \sigma^2)I_S \right) \left( \frac{r}{(r - \mu)^2} - \frac{1}{r - 2\mu - \sigma^2} \right). \quad (3.34)$$

Again, since  $\frac{(r-\mu)^2}{r} > (r - 2\mu - \sigma^2)$ ,  $\frac{r}{(r-\mu)^2} - \frac{1}{r-2\mu-\sigma^2} < 0$ . We can find a certain value of  $\tilde{p} = \sqrt{2v(r - 2\mu - \sigma^2)I_S}$  that makes the value of Eq. (3.34) equal zero. Note that  $\tilde{p} < p_J^* = p_S^*$  in this case. Thus, when  $p_t > \tilde{p}$ , the first term in Eq. (3.34) is positive, and the value of Eq. (3.34) is negative, and so is the value of Eq. (3.33), which implies that the incremental welfare of a subsidised investment minus the optimal subsidy for a JV is less than that for a WOS. The WOS will always be preferred from the host country's point of view when  $p_t > \tilde{p}$ . When  $p_t < \tilde{p}$ , the first term in Eq. (3.34) is negative and the value of Eq. (3.33) is greater than zero, implying that the incremental welfare of a subsidised investment minus the optimal subsidy for a JV is greater than that for a WOS. It should be noted that this does not necessarily mean a JV will be preferred by the host country. We need to make sure that the values of the incremental welfare of a subsidised investment minus the cost of the subsidy package (given in Eqs. (3.24) and (3.25)) are positive.

Figure 3.1 depicts what we have discussed above when values are assigned to the parameters. The figure shows the welfare of offering an investment subsidy at all price levels below the unsubsidised investment trigger for a JV and WOS. This figure assumes that the unsubsidised investment trigger points are the same. We see that the subsidised investment trigger for a JV is below the subsidised investment trigger for a WOS, but nonetheless delaying the subsidy and instead supporting a WOS has greater welfare effect.

We also note that when  $\lim p_t \rightarrow 0$ , the welfare effect is more negative for a WOS than for a JV. The reason is that the welfare effect is exactly equal to the investment cost, and because the unsubsidised investment triggers are the same, the investment cost for a WOS is greater than the investment cost for a JV. Next, we note that, at the unsubsidised investment

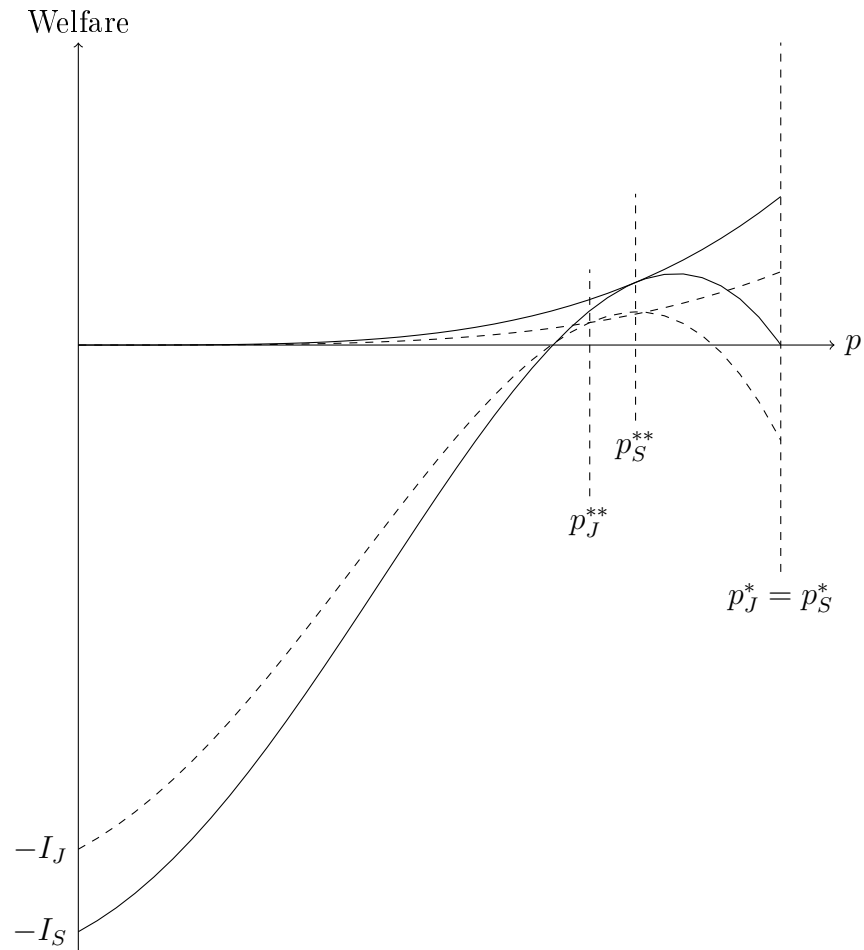


Figure 3.1: Optimal timing of investment subsidy when the unsubsidised investment triggers are identical. The dashed lines show the case of a JV; the solid lines show the case of a WOS. The parameter values used in this illustration are  $I_J = 6.667$ ,  $I_S = 7.758$ ,  $r = 10\%$ ,  $\mu = 2\%$ , and  $\sigma = 25\%$ . In this case,  $p_J^* = p_S^* = 9.289$ ,  $p_J^{**} = 6.763$ , and  $p_S^{**} = 7.369$ .

trigger,  $p_t = p_J^* = p_S^*$ , the welfare effect is zero for the WOS but negative for the JV. The reason for this is that the NPV of a WOS is greater than the NPV of a JV, and since the WOS is the outside option for the firm, the host country needs to compensate the firm for the difference in NPV for a switch to a JV.

Next, we consider the situation in which the unsubsidised NPVs of the investment in two entry modes are identical, that is,  $I_J = I_S$ . From Eqs. (3.5) and (3.8), we know that if  $I_J = I_S$ , then  $P_J^* > P_S^*$  since  $\frac{(r-\mu)^2}{r} > (r - 2\mu - \sigma^2)$ . The difference between the incremental welfare of a subsidised investment minus the optimal subsidy for a JV and for a WOS is given by Eq. (3.24 – 3.25), which is:

$$\frac{\gamma I_S}{\gamma - 1} \left( \frac{1}{p_J^{*2}} - \frac{1}{p_S^{*2}} \right) p_t^2. \quad (3.35)$$

Since  $p_J^* > p_S^*$ ,  $\frac{1}{p_J^{*2}} < \frac{1}{p_S^{*2}}$ . Thus, the value of the above expression is less than zero, implying again that the incremental welfare of a subsidised investment minus the optimal subsidy for a JV is always less than that for a WOS. The WOS will always be preferred from the host country's point of view.

Figure 3.2 shows the case in which the NPVs are identical at their respective investment trigger points. In this case, the JV model will never contribute positively to welfare for the parameter values given in this example, so there is no meaningful subsidy trigger value for this mode of entry. However, the investment cost for the WOS is lowered, which yields an even greater welfare effect, and the subsidy trigger point is lowered relative to the case in Figure 3.1. The fact that the WOS mode of entry is more attractive makes the JV mode of entry less attractive because the host country always needs to compensate the firm for the best outside option, which in this case, has enhanced profitability for the firm.

In summary, when the firm cannot choose between a JV and WOS, the host country

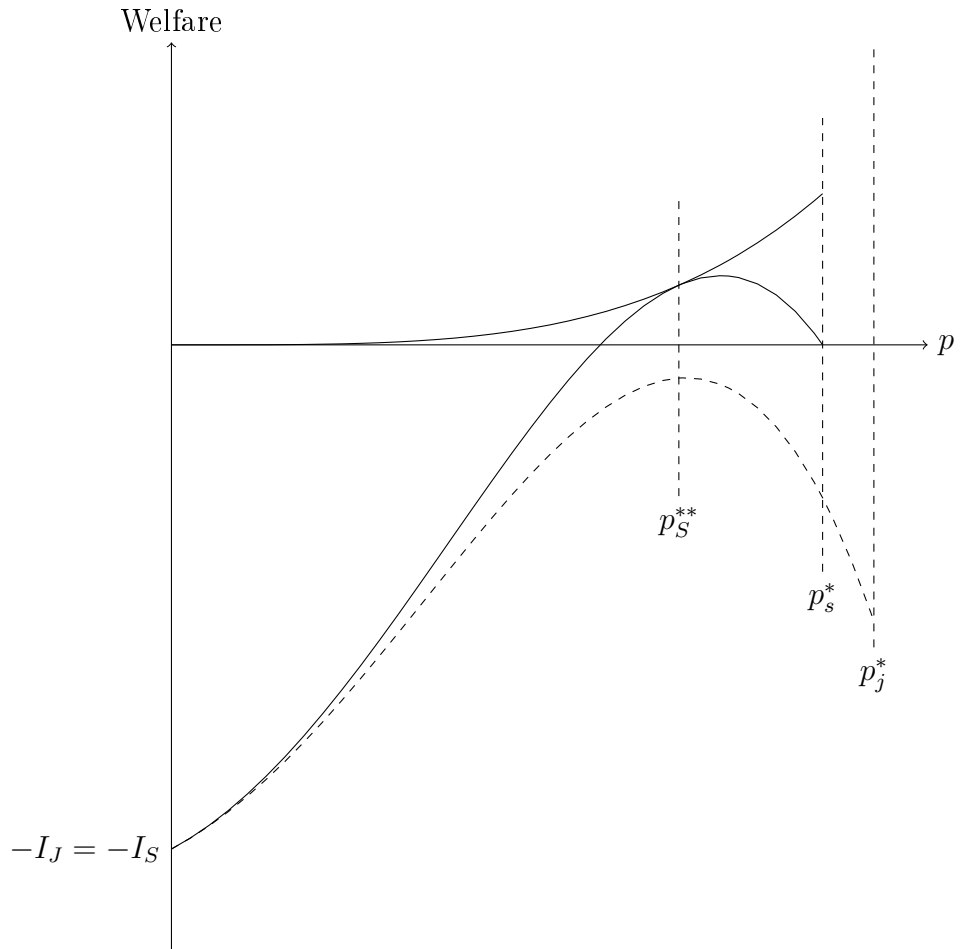


Figure 3.2: Optimal timing of investment subsidy when the unsubsidised NPVs are identical at the investment trigger points. In this case, the firm will invest sooner if the mode of entry is a JV than if the mode of entry is a WOS. The dashed lines show the case of a JV; the solid lines show the case of a WOS. The parameter values used in this illustration are  $I_J = I_S = 6.667$ ,  $r = 10\%$ ,  $\mu = 2\%$ , and  $\sigma = 25\%$ . In this case,  $p_j^* = 9.289$ ,  $p_s^* = 8.611$ , and  $p_S^{**} = 6.71$ .

prefers to offer subsidies to a JV. When the firm has the option to choose between the two entry modes, a WOS becomes more attractive to the host country.

### 3.3.3 Knowledge Transfer Benefits

The JV mode of entry has been associated with operational stability in the preceding section, but we may also consider the case in which a JV can lead to additional benefits on top of the benefit of operational stability to the host country, for example knowledge transfers. In this

section, we explore this possibility that obviously may lead to a reversal of the conclusions reached in the previous sections.

Consider a JV with an added welfare flow  $u$ , which arises from knowledge transfers. The formation of a JV through a subsidy will lead to a welfare flow that otherwise could never be achieved through unsubsidised investments (because a WOS is always the preferred choice); therefore, the added incremental welfare from a JV through knowledge transfers is just  $\frac{u}{r}$ . The question we address in this section is the following: Can we find a welfare effect of knowledge transfers associated with JVs,  $\frac{u}{r}$ , such that the host country would prefer to subsidise a JV rather than a WOS?

Note that the welfare effect of knowledge transfers does not affect the unsubsidised investment trigger  $p_J^*$ . This is because this trigger level is determined on the basis of corporate profits only and not the wider welfare effects. Next, the welfare effect of knowledge transfers does not affect the optimal subsidy of a JV,  $K_J(p_t)$ . The reason is that the subsidy is compensation to the firm for accepting a JV rather than taking the best outside option, which is a WOS, and since the welfare effect does not affect this problem, the subsidy remains the same. The only place where the welfare effect enters the problem for the host country is in the timing problem for the subsidy offer, and here the welfare effect affects the level of welfare but not the marginal welfare. Therefore, all effects of the welfare of knowledge transfers can be traced by defining a new investment cost  $I'_J = I_J - \frac{u}{r}$ . If the host country is just indifferent between the two modes of entry, the subsidy trigger for a WOS is greater than the subsidy trigger for a JV, or  $p_S^{**} > p_J^{**}$ . This situation is illustrated in Figure 3.3.

The figure demonstrates that we can always find a knowledge transfer benefit that makes the host country indifferent between a JV and WOS, but in this case, the timing of the subsidy depends on the mode of entry. A JV will be subsidised at lower price levels than a

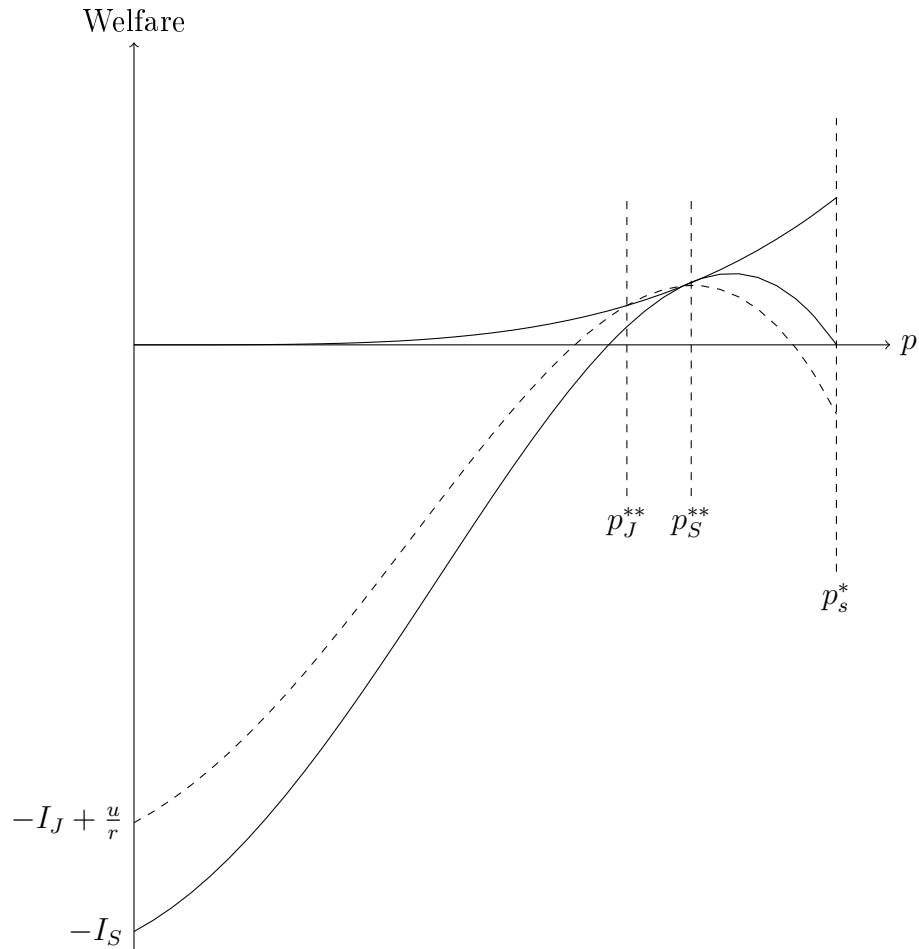


Figure 3.3: Optimal timing of investment subsidy when the JV produces additional knowledge transfer welfare. The host country is, in this case, indifferent between subsidising a JV (dashed lines) and subsidising a WOS, but the timing of the subsidy would be different depending on the mode of entry. The parameter values used in this illustration are  $I_J = 6.667$ ,  $I_S = 7.758$ ,  $u = 0.035$ ,  $r = 10\%$ ,  $\mu = 2\%$ , and  $\sigma = 25\%$ . In this case,  $p_s^* = 9.289$ ,  $p_J^{**} = 6.518$ , and  $p_S^{**} = 7.369$ .

WOS.

### 3.4 Empirical Implications

The fundamental empirical prediction in this chapter is that firms prefer FDIs, subsidised or unsubsidised, to be structured as WOSs rather than JVs.

When there is no subsidy provided, the foreign firm makes the choice of entry mode and a WOS will always be preferred since it can offer the firm full control over the production,



and this kind of 'flexibility' is valuable. Despite that, in this case, a JV is preferred by the host country from a welfare point of view.

When the host country intends to affect the foreign firm's choice of entry modes through providing subsidy packages, it prefers the WOS when the firm can choose between the two entry modes and always has the WOS as its best outside option.

In either situation, WOSs are preferred to JVs. The JVs will be used only if they can provide the host country with certain benefits that cannot be provided by WOSs, for instance, the direct access to new technology, which has benefits beyond the direct welfare benefits of the investment.

### 3.5 Conclusions

In this chapter, we analyse the timing of investment and the choice of entry modes simultaneously, and compare the entry modes of a JV and a WOS. We confirm that the choice of entry modes will affect the value of the investment project and further affect the timing of investment. We find that when there is no subsidy offered by the host country, a WOS is always preferred to a JV by the firm from a commercial point of view. The reason is that a WOS will give the firm full control over the production. The investment project in the form of a WOS would obtain higher value if it has the same investment timing as an investment project in the form of a JV. If the investments in both entry modes have the same NPVs at their respective times of investment, the investment in the form of a WOS will have a lower optimal investment trigger and thus arrive sooner. However, the welfare for the host country is always greater with a JV since the welfare effect of production output is the same for both entry modes, while the host country has an additional commercial stake in the investment in the form of a JV.

When the subsidy is provided by the host country in order to affect the firm's choice of entry modes, we can find that the WOS is more attractive to the host country through making a trade-off between the incremental welfare from speeding up the investment and the cost of providing the subsidy. The host country has to subsidise the foreign firm for its best outside option, which, in our case, is the option to invest in the form of a WOS. The investment in the form of a JV needs to be subsidised more than the investment in the form of a WOS. Therefore, the WOS mode of entry is more attractive to the host country. Either in the case in which the unsubsidised investment triggers are identical (i.e.,  $p_J^* = p_S^*$ ) or in the case in which the expected NPVs are identical (i.e.,  $I_J = I_S$ ) at their respective times of investment, the WOS will be found more attractive to the host country.

In summary, no matter whether the subsidy is offered or not, we find that a WOS will be more attractive than a JV because of its operational flexibility. A JV will be preferred only if some definable benefits from the arrangement for the host country, for example knowledge transfer benefits, can be found in addition to the direct welfare benefits of the investment.

### 3.6 Appendix

**Proof of Proposition 3.1:** We first study a JV. As mentioned in the text, the present value of the revenue stream net of cost at time  $t$  is  $V_J(p_t|q) = \frac{qp_t}{r-\mu} - \frac{vq^2}{2r}$ . The investment cost is  $I_J$ , and since the firm has veto rights over the timing of the investment, it chooses to time the investment to maximise the NPV  $V_J(p_t|q) - I_J$ . The value of the investment opportunity prior to investment can be written in the form  $Ap_t^\lambda$ , where  $\lambda > 1$  is defined in the text. The value-matching and smooth-pasting conditions  $Ap_t^\lambda = V_J(p_t|q) - I_J$  (for arbitrary constant  $A$ ) and  $\lambda Ap_t^{\lambda-1} = \frac{q}{r-\mu}$ , respectively, yields two conditions to determine both  $A$  and the investment trigger  $p_J^*$ , as follows:

$$Ap_t^\lambda = \frac{qp_t}{r-\mu} - \frac{vq^2}{2r} - I_J \quad (3A.1)$$

$$\lambda Ap_t^{\lambda-1} = \frac{q}{r-\mu}. \quad (3A.2)$$

Solving for this system of equations, we find that  $p_J^* = \frac{\lambda}{\lambda-1}(r-\mu) \left( \frac{vq}{2r} + \frac{I_J}{q} \right)$ .

Next, both parties have the incentive to choose a capacity  $q$  that maximises the NPV of the firm at the point of investment. The firm may wish to reduce output if future market conditions are poor, but the host country has veto over such a decision, so the capacity decision leads to a fixed output. We find the optimal capacity by maximising  $V_J(p_J^*|q) - I_J$ , which yields the first order condition  $\frac{p_J^*}{r-\mu} - \frac{vq^*}{r} = 0$  or  $q^* = \frac{p_J^*}{v} \frac{r}{r-\mu}$ . Substituting the optimal capacity into the expression for the trigger price above yields:

$$p_J^* = \sqrt{\frac{2v\lambda}{\lambda-2} \frac{(r-\mu)^2}{r}} I_J.$$

Given  $\lambda = 2\gamma$ , we find  $p_J^* = \sqrt{\frac{2v\gamma}{\gamma-1} \frac{(r-\mu)^2}{r}} I_J$ . Substituting  $p_J^*$  and  $q^*$  back into Eq. (3A.1),

we can find that  $A = \frac{I_J}{\gamma-1} \left( \frac{1}{p_J^*} \right)^{2\gamma}$ . Then, the value of the investment opportunity for a JV,  $V_J(p_t|p_J^*)$ , is obtained.

**Proof of the Proposition 3.2:** In this case, we can address the smooth-pasting problem directly without worrying about production capacity since output is optimal point for point, that is,  $q_t^* = \frac{p_t}{v}$ . Therefore, we find that:

$$Ap_t^\lambda = \frac{p_t^2}{2v(r-2\mu-\sigma^2)} - I_S \quad (3A.3)$$

$$\lambda Ap_t^{\lambda-1} = \frac{p_t}{v(r-2\mu-\sigma^2)}. \quad (3A.4)$$

Solving for this system of equations, we find that  $p_S^* = \sqrt{\frac{2v\lambda}{\lambda-2}(r-2\mu-\sigma^2)I_S}$ . Given  $\lambda = 2\gamma$ ,  $p_S^* = \sqrt{\frac{2v\gamma}{\gamma-1}(r-2\mu-\sigma^2)I_S}$ . Substituting  $p_S^*$  and  $q_t^*$  back into Eq. (3A.3), we can find that  $A = \frac{I_S}{\gamma-1} \left( \frac{1}{p_S^*} \right)^{2\gamma}$ . Then, the value of the investment opportunity for a WOS,  $V_S(p_t|p_S^*)$ , is obtained.

**Proof of Proposition 3.3:** Case 1: Let us first examine the welfare comparison. We find that the welfare is  $\frac{wq}{r} + (1-\alpha) \left( \frac{qp_J^*}{r-\mu} - \frac{vq^2}{2r} - I_J \right)$  for a JV and  $\frac{w}{v} \frac{p_S^*}{r-\mu}$  for a WOS. If the capacity decision is optimal, we find that the first expression becomes:  $\frac{w}{r} \frac{p_J^*}{v} \frac{r}{r-\mu} + (1-\alpha) \left( \frac{qp_J^*}{r-\mu} - \frac{vq^2}{2r} - I_J \right) = \frac{w}{v} \frac{p_J^*}{r-\mu} + (1-\alpha) \left( \frac{qp_J^*}{r-\mu} - \frac{vq^2}{2r} - I_J \right)$ , and the host country will have a share of  $(1-\alpha)$  in the NPV of the investment.

Next consider the firm's decision. The NPV of a JV is

$\alpha \left( \frac{qp_J^*}{r-\mu} - \frac{vq^2}{2r} - I_J \right)$ , and substituting for the optimal capacity and the optimal trigger price  $p_J^*$ , we find  $\alpha \left( \frac{p_J^*}{r-\mu} \frac{p_J^*}{v} \frac{r}{r-\mu} - \frac{v}{2r} \frac{p_J^{*2}}{v^2} \frac{r^2}{(r-\mu)^2} - I_J \right) = \alpha \frac{I_J}{\gamma-1}$ . The NPV of a WOS is  $\frac{p_S^{*2}}{2v(r-2\mu-\sigma^2)} - I_S$ .

Substituting for the optimal trigger price  $p_S^*$ , we find  $\frac{1}{2v(r-2\mu-\sigma^2)} 2vI_S(r-2\mu-\sigma^2) \frac{\gamma}{\gamma-1} - I_S =$

$\frac{I_S}{\gamma-1}$ . If the trigger values are the same, it follows from  $p_J^* = p_S^*$  that  $I_J \frac{(r-\mu)^2}{r} = I_S(r-2\mu-\sigma^2)$  or  $I_J = I_S \frac{r(r-2\mu-\sigma^2)}{(r-\mu)^2}$ . The factor on the right-hand side is less than one ( $r(r-2\mu-\sigma^2) < (r-\mu)^2$  reduces to  $0 < r\sigma^2 + \mu^2$ , which clearly is true), so it follows that  $I_J < I_S$ . Therefore, it follows that  $\frac{I_S}{\gamma-1} > \frac{I_J}{\gamma-1} \geq \alpha \frac{I_J}{\gamma-1}$  so the firm prefers a WOS to a JV.

Case 2: Using the above expressions, we find that if the NPVs are identical at the point of investment,  $I_J$  and  $I_S$  must be the same. This implies further that  $p_S^* < p_J^*$  so that the firm invests sooner if it invests as a WOS. The value of the investment opportunity at the point  $p_t < \min(p_J^*, p_S^*)$  is, therefore,  $\alpha \frac{I_J}{\gamma-1} \left(\frac{p_t}{p_J^*}\right)^{2\gamma}$  for a JV and  $\frac{I_S}{\gamma-1} \left(\frac{p_t}{p_S^*}\right)^{2\gamma}$  for a WOS. Since  $\alpha \leq 1$ , and since  $p_S^* < p_J^*$ , it follows that  $\alpha \frac{I_J}{\gamma-1} \left(\frac{p_t}{p_J^*}\right)^{2\gamma} \leq \frac{I_J}{\gamma-1} \left(\frac{p_t}{p_J^*}\right)^{2\gamma} < \frac{I_S}{\gamma-1} \left(\frac{p_t}{p_S^*}\right)^{2\gamma}$ , and the firm prefers to make the investment in a WOS.

Looking at welfare, it suffices to make a comparison at  $p_S^*$ , since whichever welfare is greater at this point will be preferred by the host country for all  $p_t \leq p_S^*$  (for all  $p_t > p_S^*$ , the investment decision will be made regardless of whether a subsidy is offered).

**Proof of Proposition 3.5:** This is a standard smooth-pasting problem. Take first the case of a JV. The option to offer a subsidy has value  $Ap_t^\lambda$  for some constant  $A$ ; the welfare at the optimal trigger point  $p$  is  $\frac{w}{v(r-\mu)} \left(p - p_S^* \left(\frac{p}{p_S^*}\right)^\lambda\right) + \frac{p^2}{2v(r-\mu)^2} - I_J - I_S \frac{2}{2-\lambda} \left(\frac{p}{p_S^*}\right)^\lambda$ . Therefore,

the coefficient  $A$  and the optimal trigger point  $p$  are jointly determined by the system:

$$\begin{aligned}
Ap^\lambda &= \frac{w}{v(r-\mu)} \left( p - p_S^* \left( \frac{p}{p_S^*} \right)^\lambda \right) + \frac{p^2}{2v} \frac{r}{(r-\mu)^2} - I_J - I_S \frac{2}{2-\lambda} \left( \frac{p}{p_S^*} \right)^\lambda & (\text{step 1}) \\
\lambda Ap^{\lambda-1} &= \frac{w}{v(r-\mu)} \left( 1 + p_S^* \lambda \left( \frac{p}{p_S^*} \right)^{\lambda-1} \frac{1}{p_S^*} \right) + \frac{2p}{2v} \frac{r}{(r-\mu)^2} - I_S \frac{2}{\lambda-2} \lambda \left( \frac{p}{p_S^*} \right)^{\lambda-1} \frac{1}{p_S^*} \\
Ap^\lambda &= \frac{w}{v(r-\mu)} \left( p - p_S^* \left( \frac{p}{p_S^*} \right)^\lambda \right) + \frac{p^2}{2v} \frac{r}{(r-\mu)^2} - I_J - I_S \frac{2}{2-\lambda} \left( \frac{p}{p_S^*} \right)^\lambda & (\text{step 2}) \\
Ap^\lambda &= \frac{w}{v(r-\mu)} \left( \frac{p}{\lambda} - p_S^* \left( \frac{p}{p_S^*} \right)^\lambda \right) + \frac{p^2}{v} \frac{r}{(r-\mu)^2} \frac{1}{\lambda} - I_S \frac{2}{\lambda-2} \left( \frac{p}{p_S^*} \right)^\lambda \\
0 &= \frac{wp}{v(r-\mu)} \frac{\lambda-1}{\lambda} + \frac{p^2}{2v} \frac{r}{(r-\mu)^2} \frac{\lambda-2}{\lambda} - I_J. & (\text{step 3})
\end{aligned}$$

Solving the quadratic equation in Step 3 yields the trigger point  $p_J^{**}$ .

The case of a WOS is identical, only the right-hand side with the welfare and marginal welfare are slightly different. We find the system:

$$\begin{aligned}
Ap^\lambda &= \frac{w}{v(r-\mu)} \left( p - p_S^* \left( \frac{p}{p_S^*} \right)^\lambda \right) + \frac{p^2}{2v} \frac{1}{(r-2\mu-\sigma^2)} - I_S - I_S \frac{2}{2-\lambda} \left( \frac{p}{p_S^*} \right)^\lambda & (\text{step 1}) \\
\lambda Ap^{\lambda-1} &= \frac{w}{v(r-\mu)} \left( 1 + p_S^* \lambda \left( \frac{p}{p_S^*} \right)^{\lambda-1} \frac{1}{p_S^*} \right) + \frac{2p}{2v} \frac{1}{(r-2\mu-\sigma^2)} - I_S \frac{2}{\lambda-2} \lambda \left( \frac{p}{p_S^*} \right)^{\lambda-1} \frac{1}{p_S^*} \\
Ap^\lambda &= \frac{w}{v(r-\mu)} \left( p - p_S^* \left( \frac{p}{p_S^*} \right)^\lambda \right) + \frac{p^2}{2v} \frac{r}{(r-\mu)^2} - I_J - I_S \frac{2}{2-\lambda} \left( \frac{p}{p_S^*} \right)^\lambda & (\text{step 2}) \\
Ap^\lambda &= \frac{w}{v(r-\mu)} \left( \frac{p}{\lambda} - p_S^* \left( \frac{p}{p_S^*} \right)^\lambda \right) + \frac{p^2}{v} \frac{1}{(r-2\mu-\sigma^2)} \frac{1}{\lambda} - I_S \frac{2}{\lambda-2} \left( \frac{p}{p_S^*} \right)^\lambda \\
0 &= \frac{wp}{v(r-\mu)} \frac{\lambda-1}{\lambda} + \frac{p^2}{2v} \frac{1}{(r-2\mu-\sigma^2)} \frac{\lambda-2}{\lambda} - I_S. & (\text{step 3})
\end{aligned}$$

Again, solving the quadratic equation in Step 3 yields the trigger point  $p_S^{**}$ .

To show that these triggers are less than their unsubsidised counterparts, consider the fact that both equations are of the form  $p^{**} = (p^{*2} + a^2)^{\frac{1}{2}} - a$  for some  $a > 0$ . Taking the

right-hand side and putting  $(p^{*2} + a^2)^{\frac{1}{2}} - a < p^*$  we find:

$$(p^{*2} + a^2)^{\frac{1}{2}} - a < p^* \quad (\text{step 1})$$

$$(p^{*2} + a^2)^{\frac{1}{2}} < p^* + a \quad (\text{step 2})$$

$$p^{*2} + a^2 < (p^* + a)^2 \quad (\text{step 3})$$

$$p^{*2} + a^2 < p^{*2} + a^2 + 2p^*a$$

, and with  $p^*, a > 0$  the latter equation obviously holds.

## 3.7 Guide to Notation

The table below lists the notation used in this chapter in order of appearance in the text.

Notation	Interpretation
$r$	Risk-free interest rate
$I$	Investment cost
$q_t$	Units of a good produced at time $t$
$\frac{v}{2}$	Unit variable cost to produce a good
$p_t$	Market price of a good at time $t$
$p_0$	Market price of a good at $t = 0$
$p^*$	Optimal investment trigger when no subsidy is offered
$T$	Stopping time for the event that $p_t$ reaches $p^*$ from below for the first time
$\alpha$	Percentage share of an enterprise owned by the foreign firm
$1 - \alpha$	Percentage share of an enterprise owned by the host country
$q$	Constant production
$V_J(p_t q)$	Value of the future discounted profits for a JV when production flow, $q_t$ , is kept constant at $q$
$I_J$	Investment cost for a JV
$q^*$	Optimal constant production for a JV
$p_J^*$	Optimal investment trigger for a JV trigger when no subsidy is offered



---

$V_J(p_J^* q^*)$	Value of the investment for a JV at the time of investment
$V_J(p_t p_J^*)$	Value of the investment opportunity for a JV
$I_S$	Investment cost for a WOS
$q_t^*$	Optimal variable production for a WOS
$V_S(p_t q_t^*)$	Value of the future discounted profits for a WOS when the good is produced at $q_t^*$
$V_S(p_t p_S^*)$	Value of the investment opportunity for a WOS
$p_S^*$	Optimal investment trigger for a WOS trigger when no subsidy is offered
$V_S(p_S^* q_t^*)$	Value of the investment at the time of investment for a JV
$W_J(p_t q)$	Welfare benefit for the host country when a JV produces the good at $q$
$W_J(p_t q^*)$	Welfare benefit for the host country when a JV produces the good at $q^*$
$W_S(p_t q_t^*)$	Welfare benefit for the host country when a WOS produce the good at $q_t^*$
$W_J(p_J^* q^*)$	Welfare benefit for the host country evaluated at $p_J^*$ , when a JV produces the good at $q^*$
$W_S(p_S^* q_t^*)$	Welfare benefit for the host country evaluated at $p_S^*$ , when a WOS produces the good at $q_t^*$
$K(p_t)$	Investment subsidy package whose value is a function of $p_t$
$K_J(p_t)$	Optimal subsidy package for a JV
$K_S(p_t)$	Optimal subsidy package for a WOS
$\Delta W_J(p_t)$	Incremental welfare benefits for a JV
$\Delta W_S(p_t)$	Incremental welfare benefits for a WOS

---

---

$p^{**}$	Optimal subsidy trigger
$T_S$	Stopping time when the optimal investment trigger point $p_S^*$ is reached for the first time
$p_J^{**}$	Optimal subsidy trigger for a JV
$p_S^{**}$	Optimal subsidy trigger for a WOS
$u$	Welfare flow arising from knowledge transfer in the case of a JV

---

# Chapter 4

## Competitive Product Markets

### 4.1 Introduction

In Chapter 3, we studied investment timing and choice of entry mode simultaneously. We derived decision rules of entry choice between a JV and a WOS under two cases when subsidy packages are offered by the host country and when there is no subsidy offered. However, we did not take into account the effect of industry structure and assume that the newly established firm (the JV or the WOS) is a local monopoly. Then, it is a logical step to extend our analysis to the case in which competition in the product market exists and investigate the effect of competition on the choice of entry modes when the host country has the option to speed up the investment through providing subsidy packages. This forms the direct motivation for the analysis in this chapter.

The conclusion drawn from the preceding chapter is that it can be costly for the host country to subsidise JVs unless there are specific benefits associated with such arrangements, for instance knowledge transfer benefits that arise from the fact that the host country takes a commercial stake in the investment. This conclusion is made, however, assuming the product

markets are non-competitive. Non-competitive product markets offer the firm attractive options to delay investment hoping that the market conditions will improve in the future and options to vary output according to the prices in the product markets. Either effect is less pronounced in competitive markets.

Competition imposes certain restrictions on the movement of the state variable. When product markets are assumed to be non-competitive, we usually treat the payoff of the investment project or the output price as a state variable that follows a certain process, in particular the geometric Brownian motion. Since no restrictions have been imposed, the state variable can range over  $(0, \infty)$ . However, in practice, there are always restrictions on the state variables. In a competitive industry, when the firms can enter and exit the market freely, the output price will be bounded above since new firms will enter the industry if the output price exceeds a certain level and the investment becomes profitable. Because there are more firms in production, the total output will increase. The increase in aggregate supply will bring the output price down. The output price will also be bounded below since existing firms will leave the industry if the output price falls below a certain level and the firms suffer losses. Since fewer firms are in production, the total output will decrease and the reduction in aggregate supply will cause the output price to rise. Therefore, the free entry to and exit from a competitive market will result in both the upper and lower bounds of the state variable. In this chapter, we study the firms' investment timing and entry mode when the output price is regulated. We attempt to address the following issues: a) When the market is competitive, how do entry and exit of firms affect the valuation of the investment projects and the investment thresholds? b) What are the effects of product market competition on the values of the investment projects and the timing of investment when different entry modes are adopted? c) How should the host country subsidise the firms to speed up the

investment under this market structure? We also try to investigate whether one entry mode will be preferred under this market structure.

The analysis in this chapter relates to several strands of literature. One strand refers to the framework of dynamic contingent claims analysis. Brennan and Schwartz (1984), Mello and Parsons (1992), and Mauer and Triantis (1994) studied the interaction between investment, production and foreclosure, and financing decisions. Leland (1994) and Leland and Toft (1996) analysed the effect of firm's foreclosure on optimal capital structure and the valuation of bonds with infinite and finite maturity, respectively. All these models assume that the firm has monopolistic access to the investment. In addition to the literature that considers the monopoly case, Lambrecht (2001) studied an intermediate duopoly case that requires the modelling of strategic behaviour between the firms. He provided a dynamic contingent claims model of strategic entry and exit in a duopoly. He found the factors that determine the order in which firms exit. When it comes to market entry, he found that the need to borrow money will delay a firm's entry, while the financial vulnerability of the incumbent induces earlier entry.

The approach we take in this chapter follows Dixit (1989), Leahy (1993), Fries *et al.* (1997) and Miao (2005). Dixit (1989) examined the entry and exit decisions under uncertainty by assuming the output price follows a diffusion motion. His model considers a single firm with two states: when the firm is idle, it decides whether to continue being idle or to enter and, when the firm is active, it decides whether to continue being active or to exit. He analytically derived a pair of entry and exit triggers. While Dixit (1989) in effect assumed that the firm is a monopolist, Leahy (1993) extended Dixit's (1989) model to the case in which a firm faces competitors and investigates the investment decisions in competitive equilibrium. He considered two types of firm – firms that consider the actions of the competitors

and the firms that ignore the actions of the competitors – and showed that competition does not affect investment timing at all, in the sense that the investment triggers for the two types of firms are identical. While both the models of Dixit (1989) and Leahy (1993) assumed pure equity financing of the firm, Fries *et al.* (1997) considered the effect of the financial structure on firm valuation. They started from a single-firm benchmark model, in which the output price is exogenously given, to the case of a competitive equilibrium, in which the output price is endogenously determined. They studied how the options of entry and exit affect the valuation of the firm's equity and debt and derived its optimal capital structure. They also showed how the firm will optimally adjust the leverage and priced the firm with leverage adjustments. Miao (2005) studied the production/investment decisions, the capital structure choices, and their interactions in a competitive equilibrium model. The firms' financing, entry, exit, and production decisions are subject to idiosyncratic technology shocks and are chosen to maximise equity value after debt is in place. To reach the optimal capital structure, the firm needs to make trade-offs between tax benefits of debt and the associated bankruptcy and agency costs. His analysis confirms the existence of a price feedback effect in the competitive equilibrium model.

This chapter also relates to the literature on the choice of entry mode from a real option perspective, as we have mentioned in Chapter 3.

In our analysis, it should be noted that competition imposes certain cost structures on the firm. A competitive market will attract only potential entrants that can compete in an unsubsidised environment. Therefore, if JVs and WOSs are available as targets for subsidy, they must also be potentially viable enterprises in an unsubsidised environment. In the preceding chapter, we assumed that the unsubsidised mode of entry is either comparable in terms of timing or comparable in terms of NPV. When we are looking at entry into

competitive markets, we need to assume that both modes of entry are competitive without subsidy, which means that both the timing and the NPV must be the same. This is only feasible if the cost structures are different for the firm established in different forms, and we consider the simplest cost structure such that both modes of entry are competitive. Some fixed cost is introduced in the case of a WOS, which is consistent with the finding that a WOS usually requires higher initial investment cost than a JV (Li and Rugman, 2007).

This chapter is organised as follows. Section 4.2 describes the output price in a competitive industry in which a large number of firms who can enter and exit the industry freely exist and presents the derivation of the value functions for a JV and WOS. Section 4.3 discusses the firms' optimal entry and exit policy when different market entry modes are adopted and there is no subsidy offered, and presents the derivation of the cost structure that is required for both a JV and WOS to be competitive. The respective welfare for the host country when different entry modes are used is also derived in this section. Section 4.4 presents the benefits of the option to speed up the firms' entry into an industry using investment subsidy. The respective optimal subsidy package for a JV and WOS is derived. The welfare from unsubsidised entry before it happens is also derived for both cases. The optimal investment triggers are also determined when different entry modes are chosen. Section 4.5 concludes the chapter.

## 4.2 Competitive Product Markets

Suppose product prices are influenced in two ways:

$$p_t = x_t D(Q_t), \quad (4.1)$$

where  $x_t$  is a state variable describing random demand shocks, and  $D(q_t)$  is a function measuring the price effect of the aggregate quantity decisions  $Q_t$  of the firms producing the product. This formulation is assumed, for instance, by Fries *et al.* (1997), who utilised the mathematical derivations of Harrison (1985). We assume here that  $D(Q_t)$  is a decreasing function of aggregate quantity  $Q_t$ , such that net entry into the industry that leads to an increase in  $Q_t$  puts downward pressure on the product prices. Similarly, net exit leads to an increase in the product prices. The uncertainty of demand channelled through the state variable  $x_t$  is the same as in the standard model. We assume that  $x_t$  is a geometric Brownian motion with drift  $\mu$  and volatility  $\sigma$ . As usual, in the literature, the drift rate  $\mu$  is assumed to be smaller than the risk-free rate of interest, denoted by  $r$ . We can derive the price dynamics as follows:

$$dp_t = p_t \frac{D'(Q_t)}{D(Q_t)} dQ_t + \mu p_t dt + \sigma p_t dB_t, \quad (4.2)$$

where  $dB_t$  is a standard Brownian motion.

Assuming a large number of firms enter or exit the industry seamlessly, output will increase if prices rise above a certain threshold, and output will decrease if prices fall below a certain threshold, such that prices will become regulated at the threshold points, where  $dQ_t \neq 0$ , but will otherwise behave according to a geometric Brownian motion with drift  $\mu$  and volatility  $\sigma$ .

If entry and exit decisions are instantaneous, the price process becomes a doubly absorb-



ing barrier process that satisfies:

$$dp_t = \mu p_t dt + \sigma p_t dB_t + dM_t^+ + dM_t^-, \quad (4.3)$$

where  $M_t^+$  and  $M_t^-$  are stochastic regulator processes that apply at the barrier entry point  $p_E$  and the barrier exit point  $p_B$ :

$$M_t^+ = \sup_{0 \leq \tau \leq t} \min(p_E - (p_\tau - p_B) - M_t^-, 0) \quad (4.4)$$

$$M_t^- = \sup_{0 \leq \tau \leq t} \min(p_\tau - p_E - M_t^+, 0). \quad (4.5)$$

For price levels  $p_B < p_t < p_E$ , the stochastic regulators do not kick in, and the price process reverts to a regular geometric Brownian motion with drift  $\mu$  and diffusion  $\sigma$ . We derive the barrier points  $p_E$  and  $p_B$  as the optimal entry and exit price levels, respectively, where, at entry, the NPV of entry is zero, and, at exit, the present value of continuation is zero.

In competitive industries, we expect the investment trigger points to coincide with the upper barrier point for product prices for the most competitive firms. Uncompetitive firms will, therefore, never enter the industry without some form of investment incentive. Similarly, the exit trigger points should also coincide for the most competitive firms. Uncompetitive firms would otherwise exit sooner than the competitive ones; therefore, these firms would not populate the industry in the long run. Thus, the entry and exit price levels impose constraints on the cost structure of the firms in the industry if all firms are assumed to be equally competitive in cost and flexibility structures.

Consider first the case of a JV, where the firm and the host country jointly invest  $I_J$  to set up a production facility that produces a fixed quantity  $q$ . We assume that this organisational structure is competitive so that the investment trigger coincides with the entry barrier, and

the shut-down barrier coincides with the exit barrier. The value function for an established JV that produces a fixed quantity  $q$  is given by:

$$V_J(p_t|q) = Ap_t^{\lambda_1} + Bp_t^{\lambda_2} + \left( \frac{p_t q}{r - \mu} - \frac{v_J}{2} \frac{q^2}{r} \right), \quad (4.6)$$

where  $\frac{v_J}{2}$  is the unit variable cost of the fixed output  $q$ .<sup>1</sup> The third term in this expression relates to the value of producing in an environment where there are no price barriers, and the two first terms relate to the correction to the value function associated with reaching an absorbing upper barrier where the product price can go no further upwards and with reaching an absorbing lower barrier where the product price can go no further downwards. The constants  $A$  and  $B$  are decided in such a way that entry is just profitable at the upper barrier and exit is just profitable at the lower barrier. The parameters  $\lambda_1$  and  $\lambda_2$  are given by:  $\lambda_1 = \left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right) + \left(\left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right)^2 + \frac{2r}{\sigma^2}\right)^{\frac{1}{2}} > 1$  and  $\lambda_2 = \left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right) - \left(\left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right)^2 + \frac{2r}{\sigma^2}\right)^{\frac{1}{2}} < 0$ , respectively.

Note that the production quantity enters the value function only through the third term. If the capacity  $q$  could be chosen freely, it would be chosen such that it maximises the term  $\left( \frac{p_t q}{r - \mu} - \frac{v_J}{2} \frac{q^2}{r} \right)$ , which yields the same optimal capacity as we found in the preceding chapter, namely  $q^* = \frac{p_t}{v_J} \frac{r}{r - \mu}$ . The value function can, therefore, be rewritten as:

$$V_J(p_t|q^*) = Ap_t^{\lambda_1} + Bp_t^{\lambda_2} + \frac{p_t^2}{2v_J} \frac{r}{(r - \mu)^2}. \quad (4.7)$$

In the case of a WOS, where the firm invests  $I_S$  to set up a production facility that produces an optimal quantity determined by point-for-point value maximisation. We assume

---

<sup>1</sup>We do not take into account personal and corporate taxes in this chapter since it will not alter our conclusions but add more complexity to the analysis. Please note that taking into account debt may alter the results.

that this organisational structure is also competitive so that the investment trigger coincides with the entry barrier in the market, and the shut-down barrier coincides with the exit barrier. The cash flow of an established WOS is  $(p_t q_t - \frac{v_S}{2} q_t^2 - f)$ , where  $\frac{v_S}{2}$  is the unit variable cost parameter associated with the output  $q_t$  and  $f$  is the fixed cost of production. Maximising with respect to  $q_t$  yields  $p_t - v_S q_t = 0$  or  $q_t^* = \frac{p_t}{v_S}$ . The value function for an established WOS that produces a variable quantity  $q_t^*$  is, therefore, given by:

$$\begin{aligned} V_S(p_t|q_t^*) &= Ap_t^{\lambda_1} + Bp_t^{\lambda_2} + \left( \frac{p_t^2}{v_S(r - 2\mu - \sigma^2)} - \frac{p_t^2}{2v_S(r - 2\mu - \sigma^2)} - \frac{f}{r} \right) \\ &= Ap_t^{\lambda_1} + Bp_t^{\lambda_2} + \left( \frac{p_t^2}{2v_S} \frac{1}{r - 2\mu - \sigma^2} - \frac{f}{r} \right). \end{aligned} \quad (4.8)$$

### 4.3 Unsubsidised Entry and Exit

In this section, we make an analysis of the firms' investment policy in an unsubsidised competitive industry and the welfare of host countries within which these investments are made.

#### 4.3.1 Optimal Entry and Exit

Competitiveness for a JV implies that the NPV of entry at  $p_E$  is zero and the NPV of exit at  $p_B$  is also zero. Moreover, since these price levels are absorbing barriers, the expected marginal value is exactly zero. This generates the following results.

**Proposition 4.1: Competitive JVs** *For a JV investment to be competitive in an industry with entry price trigger  $p_E$  and exit price trigger  $p_B$ , the following condition needs to be satisfied:*

$$\begin{pmatrix} \lambda_1 p_E^{\lambda_1} & \lambda_2 p_E^{\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} p_E^2 \\ p_B p_E \end{pmatrix} = \begin{pmatrix} p_E^{\lambda_1} & p_E^{\lambda_2} \\ p_B^{\lambda_1} & p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} \frac{p_E^2}{2} - v_J I_J \frac{(r-\mu)^2}{r} \\ p_E p_B - \frac{p_E^2}{2} \end{pmatrix}. \quad (4.9)$$

**Proposition 4.2: Competitive WOS** *For a WOS investment to be competitive in the same industry, the following condition needs to be satisfied:*

$$\begin{pmatrix} \lambda_1 p_E^{\lambda_1} & \lambda_2 p_E^{\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} p_E^2 \\ p_B^2 \end{pmatrix} = \begin{pmatrix} p_E^{\lambda_1} & p_E^{\lambda_2} \\ p_B^{\lambda_1} & p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} \frac{p_E^2}{2} - v_S I_S (r - 2\mu - \sigma^2) - v_S f \frac{r-2\mu-\sigma^2}{r} \\ \frac{p_B^2}{2} - v_S f \frac{r-2\mu-\sigma^2}{r} \end{pmatrix}. \quad (4.10)$$

We can use Propositions 4.1 and 4.2 to determine the cost structures for which both modes of entry are competitive at the same time. We find the following.

**Proposition 4.3: Cost Structure** *Provided the following conditions are satisfied, both a JV and WOS are competitive:*

$$\begin{pmatrix} \lambda_1 p_E^{\lambda_1} & \lambda_2 p_E^{\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} 0 \\ (p_E - p_B)p_B \end{pmatrix} = \begin{pmatrix} p_E^{\lambda_1} & p_E^{\lambda_2} \\ p_B^{\lambda_1} & p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} v_S I_S(r - 2\mu - \sigma^2) - v_J I_J \frac{(r-\mu)^2}{r} + v_S f \frac{r-2\mu-\sigma^2}{r} \\ -\frac{(p_E-p_B)^2}{2} + v_S f \frac{r-2\mu-\sigma^2}{r} \end{pmatrix}. \quad (4.11)$$

We notice that the modes of entry could have the same investment cost, but then there must be a variable cost differential, or alternatively the modes of entry could have the same variable cost, but then there must be an initial investment cost differential. It is necessary, however, that the WOS operates with a fixed cost that a JV does not have. The reason for this is that a JV with fixed output carries a fixed cost component in maintaining output when the market price is low. The finding that a WOS usually requires higher investment cost is consistent with the findings of Li and Rugman (2007). The WOS will be able to scale back production. Thus, in order for both types of firms to exit at the same time, we need to impose a fixed cost on a WOS. Alternatively, since the JV maintains fixed output, the fixed cost component can be embedded in the variable cost component. Either interpretation can apply.

In the following, we make use of a variable cost differential with identical investment cost  $I$  for both modes of entry. If we make assumptions about the entry and exit prices, we can then back-track what implications this has on the cost structures for the two modes of entry. By taking  $r$ ,  $\mu$ , and  $\sigma$  as exogenous parameters, satisfying  $r - 2\mu - \sigma^2 > 0$ , and by specifying  $p_E$ ,  $p_B$ ,  $I$ , and  $v_S$ , we will automatically be given  $v_J$  and  $f$ . The only constraint

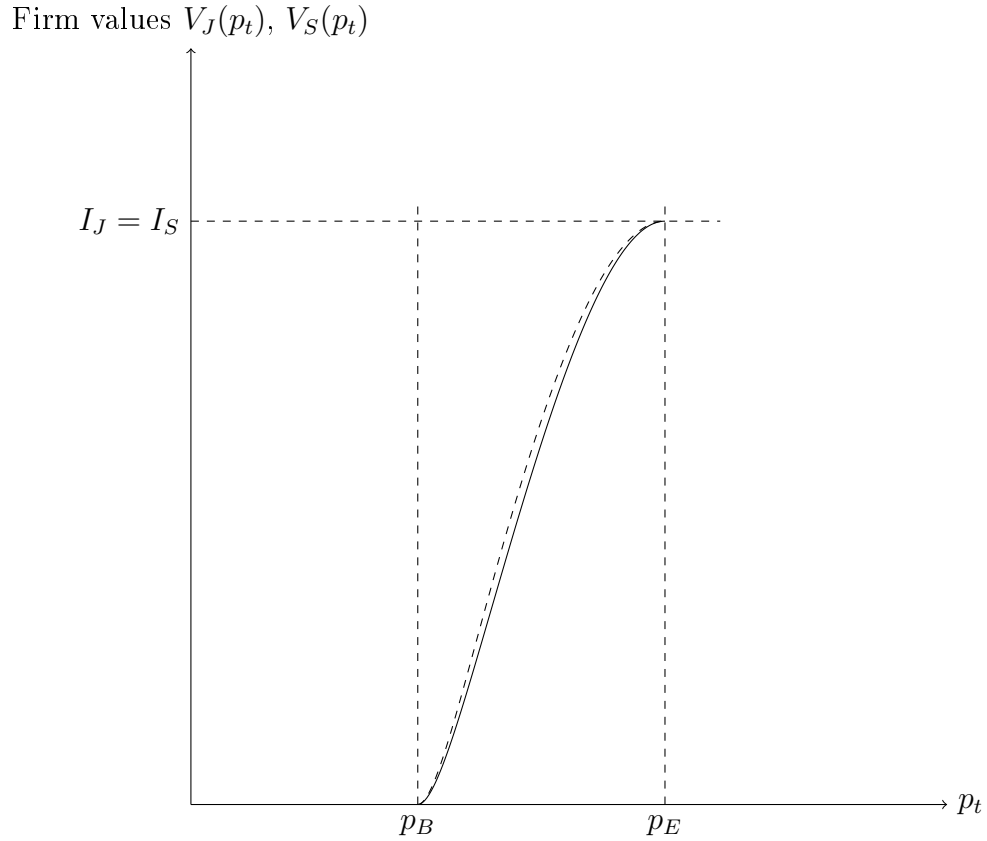


Figure 4.1: Optimal entry and exit in competitive industries. The figure shows the firm values associated with JVs (dashed lines) and WOSs (solid lines). The parameter values used in this illustration are  $I_J = I_S = 7.714$ ,  $v_S = 0.05$ ,  $r = 12\%$ ,  $\mu = 2\%$ , and  $\sigma = 25\%$  in order to guarantee that  $r - 2\mu - \sigma^2 > 0$ . In this case,  $p_B = 3$  and  $p_E = 6.269$ .

is that all cost parameters need to be positive. With these constraints in mind, we continue to examine subsidised investments.

Figure 4.1 shows the firm values associated with a JV and WOS, and we notice that, given that the two organisational structures have cost structures that allow them to be competitive (i.e., they both have the same exit and entry trigger points to the industry), the commercial value of a JV is greater than the commercial value of a WOS. The JV will eventually endure a higher cost associated with maintaining the output flow, and this prompts exit at the exit trigger, while the WOS will eventually endure a higher fixed cost component in production, which otherwise can be scaled back to reduce variable costs, and this prompts exit at the exit trigger.

### 4.3.2 Welfare in Competitive Industries

Since we operate in a competitive industry, the country has the same chance of gaining an investment at the entry point as any other country and the same chance of losing an investment at the exit point as any other country. Therefore, the welfare of the investments made in the industry when it is unsubsidised can be normalised to zero. We can then investigate the welfare of subsidised entry into the industry as the welfare flow until the entry trigger point  $p_E$  is reached.

It is, however, of interest to investigate, in the case in which there is commercial indifference between the modes of entry, whether indifference in welfare terms also exist. We assume the welfare flow can be quantified as  $w$  per unit of output. For a JV, this is just a constant flow  $wq$ , but, for a WOS, this is a variable flow  $wq_t^*$ . We find the following result.

**Proposition 4.4 (Unsubsidised Welfare):** *The welfare of a firm that has entered the industry as a JV can be written as:*

$$W_J(p_t) = \left[ \begin{pmatrix} \lambda_1 p_E^{\lambda_1} & \lambda_2 p_E^{\lambda_2} \\ (\lambda_1 - \eta) p_B^{\lambda_1} & (\lambda_2 - \eta) p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} 0 \\ \eta \frac{w}{v_J} \frac{p_E}{r - \mu} \end{pmatrix} \right]^\top \begin{pmatrix} p_t^{\lambda_1} \\ p_t^{\lambda_2} \end{pmatrix} + \frac{w}{v_J} \frac{p_E}{r - \mu}, \quad (4.12)$$

and the welfare of a firm that has entered the industry as a WOS can be written as:

$$W_S(p_t) = \left[ \begin{pmatrix} \lambda_1 p_E^{\lambda_1} & \lambda_2 p_E^{\lambda_2} \\ (\lambda_1 - \eta) p_B^{\lambda_1} & (\lambda_2 - \eta) p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} -\frac{w}{v_S} \frac{p_E}{r - \mu} \\ -(1 - \eta) \frac{w}{v_S} \frac{p_B}{r - \mu} \end{pmatrix} \right]^\top \begin{pmatrix} p_t^{\lambda_1} \\ p_t^{\lambda_2} \end{pmatrix} + \frac{w}{v_S} \frac{p_t}{r - \mu}, \quad (4.13)$$

where  $\eta$  is the exit rate from the industry at the lower boundary point, which can be interpreted as the exit flow that is necessary to support the exit trigger point.

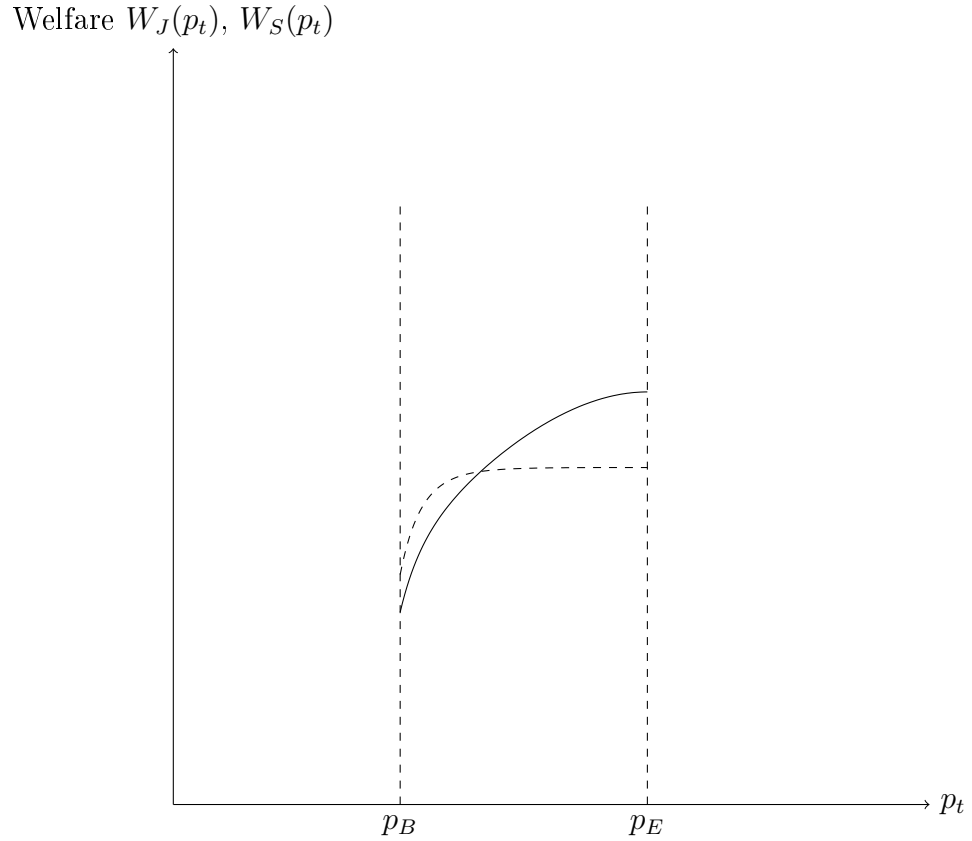


Figure 4.2: Unsubsidised welfare in competitive industries. The figure shows the welfare associated with JVs (dashed lines) and WOSs (solid lines). The parameter values used in this illustration are  $v_S = 0.05$ ,  $r = 12\%$ ,  $\mu = 2\%$ , and  $\sigma = 25\%$  in order to guarantee that  $r - 2\mu - \sigma^2 > 0$ . Moreover,  $p_B = 3$  and  $p_E = 6.269$ . The welfare flow,  $w$ , is assumed to be 0.48, and the exit rate,  $\eta$ , is assumed to be 5%.

Since these expressions are different, they may not generate the same welfare effect even though, in commercial terms, they generate the same profits and the same timing of entry to and exit from the industry.

The figure shows that the welfare effect with JVs is less affected by the price in the product market, and this is because the welfare flow is related to output, which is stable with JVs. With WOSs, the welfare effect is stronger than for JVs when the market price is high but lower than for JVs when the market price is low. There is, therefore, a point at which the welfare effect is the same regardless.



If investment has not happened yet, the welfare effect is the expected value of the welfare of an investment at the entry price trigger. The value of the firm is exactly equal to the investment cost at the entry trigger point regardless of mode of entry, so the firm is indifferent between entry as a WOS and as a JV, so the host country will prefer that the mode of entry is the one with the maximum welfare effect, which is a WOS in the case of the figure above. However, we notice that if a subsidy is considered, it may be better to subsidise a JV in some states of nature because both the commercial value of the firm is greater and the welfare effect on the host country is greater with this mode of entry compared to a WOS.

## 4.4 Subsidised Mode of Entry

In this section, we look at the benefits of the option to speed up entry into the industry using investment incentives. We assume that such entry is small and will not affect the product prices even though the entry will happen between the entry price trigger point and the exit price trigger point. We first look at the optimal subsidy, then we look at the optimal timing of subsidy given the mode of entry, and finally the optimal mode of entry for the subsidy.

### 4.4.1 Optimal Subsidy and Optimal Timing

If the host country wants to subsidise early investment and gain the welfare  $w$ , it must compensate the firm for the costs. In Chapter 2, we show that this is done by providing the firm with the difference between the value of the investment cost and the actual value of the investment. Therefore, we find the following result.

**Proposition 4.5** *The optimal subsidy offered at the price  $p_t = p$  is given by the following*

expressions. For subsidised JVs, the subsidy  $K_J(p)$  is given by:

$$K_J(p) = -\alpha(V_J(p) - I_J), \quad (4.14)$$

where  $\alpha$  is the stake of the firm in the JV,  $V_J(p)$  is the present value of the investment at the price  $p$ , and  $I_J$  is the investment cost. For subsidised WOSs, the subsidy  $K_S(p)$  is given by:

$$K_S(p) = -(V_S(p) - I_S), \quad (4.15)$$

where  $V_S(p)$  is the present value of the investment at the price  $p$ , and  $I_S$  is the investment cost.

Next, we look at the problem of optimal timing of subsidy. The incremental welfare from subsidising early entry into an industry is defined as the welfare of the investment minus the welfare from the unsubsidised entry, which would happen in any case at the competitive industry entry point. Therefore, we need an expression for the welfare from unsubsidised entry before it happens. The following result demonstrates the expressions for a JV and WOS.

**Proposition 4.6** *The welfare from unsubsidised entry in the form of a JV, before it has happened, is given by  $\bar{W}_J(p)$ , where:*

$$\bar{W}_J(p) = \left[ \begin{pmatrix} p_E^{\lambda_1} & p_E^{\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} W_J(p_E) \\ 0 \end{pmatrix} \right]^\top \begin{pmatrix} p^{\lambda_1} \\ p^{\lambda_2} \end{pmatrix}. \quad (4.16)$$

The corresponding expression for a WOS is  $\bar{W}_J(p)$ , where:

$$\bar{W}_S(p) = \left[ \begin{pmatrix} p_E^{\lambda_1} & p_E^{\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} W_S(p_E) \\ 0 \end{pmatrix} \right]^\top \begin{pmatrix} p^{\lambda_1} \\ p^{\lambda_2} \end{pmatrix}. \quad (4.17)$$

The welfare from unsubsidised entry for is, therefore,  $\bar{W}(p) = \max(\bar{W}_J(p), \bar{W}_S(p))$ , which means that the incremental welfare from offering a subsidy in the form of a JV is  $W_J(p) - \bar{W}(p)$  and in the form of a WOS is  $W_S(p) - \bar{W}(p)$ .

The option to offer a subsidy for a JV can be studied as the option to collect the welfare flow  $W_J(p) - K_J(p) - \bar{W}(p)$ , and the option to offer a subsidy for a WOS investment as the option to collect the welfare flow  $W_S(p) - K_S(p) - \bar{W}(p)$ . The following result yields the timing.

**Proposition 4.7** *The optimal timing of a subsidised JV is given by the trigger point  $p_J^{**}$ , satisfying the relationship:*

$$\begin{aligned} & \Xi_J^\top \begin{pmatrix} p_J^{**\lambda_1} \\ p_J^{**\lambda_2} \end{pmatrix} + \frac{p_E}{v_J} \frac{r}{(r-\mu)^2} \left( p_J^{**} - \frac{p_E}{2} \right) - I_J + \frac{w}{v_J} \frac{p_E}{r-\mu} \\ &= \left( \begin{pmatrix} \lambda_1 p_J^{**\lambda_1} & \lambda_2 p_J^{**\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \left( \Xi_J^\top \begin{pmatrix} \lambda_1 p_J^{**\lambda_1} \\ \lambda_2 p_J^{**\lambda_2} \\ 0 \end{pmatrix} + \frac{p_J^{**} p_E}{v_J} \frac{r}{(r-\mu)^2} \right) \right)^\top \begin{pmatrix} p_J^{**\lambda_1} \\ p_J^{**\lambda_2} \end{pmatrix}, \end{aligned} \quad (4.18)$$

where  $\Xi_J$  is given by:

$$\begin{aligned} \Xi_J = & \left( \begin{pmatrix} \lambda_1 p_E^{\lambda_1} & \lambda_2 p_E^{\lambda_2} \\ (\lambda_1 - \eta) p_B^{\lambda_1} & (\lambda_2 - \eta) p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} 0 \\ \eta \frac{w}{v_J} \frac{p_E}{r - \mu} \end{pmatrix} - \begin{pmatrix} p_E^{\lambda_1} & p_E^{\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \right. \\ & \times \left. \begin{pmatrix} (W_S(p_E) \vee W_J(p_E)) \\ 0 \end{pmatrix} - \begin{pmatrix} p_E^{\lambda_1} & p_E^{\lambda_2} \\ p_B^{\lambda_1} & p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} \frac{p_E^2}{2v_J} \frac{r}{(r - \mu)^2} - I_J \\ \frac{p_E}{v_J} \frac{r}{(r - \mu)^2} (p_B - \frac{p_E}{2}) \end{pmatrix} \right), \quad (4.19) \end{aligned}$$

where  $(\cdot \vee \cdot)$  denotes the maximum operator.

It should be noted that this result assumes that a JV established at a point  $p_J^{**} < p_E$  will produce at the same capacity as a JV established at the entry trigger point  $p_E$ . If we allow the JV to produce at a different capacity with subsidised entry and with unsubsidised entry, then it will no longer satisfy the conditions for competitiveness, since the capacity decision effects the cost structure of the firm. To avoid this problem, we simply assume the subsidised JV is identical to the unsubsidised JV. This problem will not arise with a WOS since the output is a direct function of the prevailing market price, so the subsidised WOS will produce with the exact same cost structure as the unsubsidised WOS; the only difference is the timing of entry. To make the situation similar for a JV, we simply assume the same capacity decisions are made regardless of the timing of entry.

**Proposition 4.8** *The optimal timing of a subsidised JV is given by the trigger point  $p_S^{**}$ ,*

satisfying the relationship:

$$\begin{aligned}
& \Xi_S^\top \begin{pmatrix} p_S^{**\lambda_1} \\ p_S^{**\lambda_2} \end{pmatrix} + \frac{p_S^{**2}}{2v_S} \frac{1}{r-2\mu-\sigma^2} - \frac{f}{r} - I_S + \frac{w}{v_S} \frac{p_S^{**}}{r-\mu} \\
&= \left( \begin{pmatrix} \lambda_1 p_S^{**\lambda_1} & \lambda_2 p_S^{**\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} \Xi_S^\top \begin{pmatrix} \lambda_1 p_S^{**\lambda_1} \\ \lambda_2 p_S^{**\lambda_2} \end{pmatrix} + \frac{p_S^{**2}}{v_S} \frac{1}{r-2\mu-\sigma^2} + \frac{w}{v_S} \frac{p_S^{**}}{r-\mu} \\ 0 \end{pmatrix} \right)^\top \begin{pmatrix} p_S^{**\lambda_1} \\ p_S^{**\lambda_2} \end{pmatrix}, \tag{4.20}
\end{aligned}$$

where  $\Xi_S$  is given by:

$$\begin{aligned}
\Xi_S &= \left( \begin{pmatrix} \lambda_1 p_E^{\lambda_1} & \lambda_2 p_E^{\lambda_2} \\ (\lambda_1 - \eta) p_B^{\lambda_1} & (\lambda_2 - \eta) p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} -\frac{w}{v_S} \frac{p_E}{r-\mu} \\ -(1-\eta) \frac{w}{v_S} \frac{p_B}{r-\mu} \end{pmatrix} - \begin{pmatrix} p_E^{\lambda_1} & p_E^{\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \right. \\
&\quad \times \left. \begin{pmatrix} (W_S(p_E) \vee W_J(p_E)) \\ 0 \end{pmatrix} - \begin{pmatrix} p_E^{\lambda_1} & p_E^{\lambda_2} \\ p_B^{\lambda_1} & p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} \frac{p_E^2}{2v_S} \frac{1}{r-2\mu-\sigma^2} - \frac{f}{r} - I_S \\ \frac{p_B^2}{2v_S} \frac{1}{r-2\mu-\sigma^2} - \frac{f}{r} \end{pmatrix} \right), \tag{4.21}
\end{aligned}$$

where  $(\cdot \vee \cdot)$  denotes the maximum operator.

The following figure shows the optimal trigger points for the subsidised JV and WOS.

The figure shows the same familiar picture we obtain in non-competitive industries: the option to offer an investment subsidy has greater value for WOSs than for JVs. Therefore, JVs need to offer a welfare effect beyond the welfare effect associated with output in order to be an attractive mode of subsidised entry into an industry.

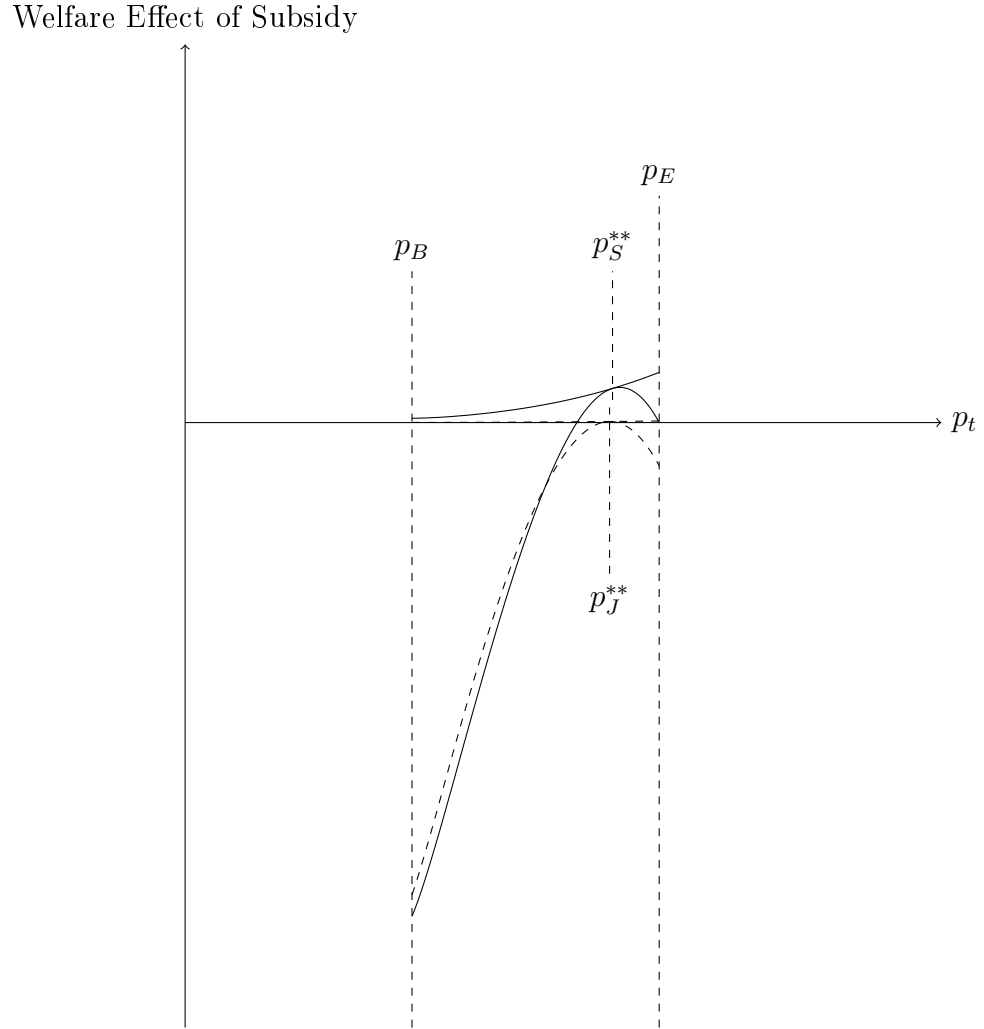


Figure 4.3: Welfare effects of subsidy in competitive industries. The figure shows the welfare effect of investment subsidy, the welfare effect of the option to offer investment subsidy, and the optimal subsidy trigger points where the two coincide, associated with JVs (dashed lines) and WOSs (solid lines). The parameter values used in this illustration are  $v_S = 0.05$ ,  $r = 12\%$ ,  $\mu = 2\%$ , and  $\sigma = 25\%$  in order to guarantee that  $r - 2\mu - \sigma^2 > 0$ . Moreover,  $p_B = 3$  and  $p_E = 6.269$ . The welfare flow,  $w$ , is assumed to be 0.48, and the exit rate,  $\eta$ , is assumed to be 5%. In this case,  $p_J^{**} = 5.613$  and  $p_S^{**} = 5.652$ .

## 4.5 Conclusions

In this chapter, we introduce product market competition into our analysis. In a competitive industry, when firms can enter and exit the industry freely, the net entry into the industry leads to an increase in aggregate production and puts downward pressure on the product prices while the net exit leads to an increase in the product prices. Then, the process of the output price becomes a doubly absorbing barrier process. The upper barrier actually coincides with the entry trigger point and the lower barrier coincides with the exit trigger point.

Our result suggests that when no subsidy is offered, the firms must have the same investment and disinvestment triggers so that both JVs and WOSs are equally competitive in the sense they have the same entry trigger and exit trigger points as all other firms in the industry. This condition imposes some constraints on the cost structure of the firms. It is necessary for a WOS to operate with a fixed cost that a JV does not have.

Although a JV and WOS are equally competitive, the welfare effects of unsubsidised entry are not the same. We find by numerical evaluation that, with WOSs, the welfare effect is lower than that for JVs when the market price is low since the welfare flow is related to stable output with JVs. When the market price is high, the welfare effect of unsubsidised entry is greater when the mode of entry is a WOS than when it is a JV. This is also owing to the operational inflexibility of JVs.

When a subsidy is offered by the host country, we look at the optimal subsidy, the optimal timing of subsidy given the mode of entry, and the optimal mode of entry for the subsidy. It is very difficult to derive closed-form solutions. To examine the empirical implications, we assign values to the variables and obtain Fig. 4.3, which is similar to the figure we obtain for non-competitive industries. The main conclusion from Chapter 3 is that

a subsidy should favour the most operationally efficient enterprise. We add to this in this chapter by studying the subsidy of investments in competitive industries – where operational efficiency is not really well defined, as we make the assumption that both modes of entry are equally competitive. Still, we find that the subsidy should favour the most operationally flexible mode of entry. This is a surprising finding.



## 4.6 Appendix

**Proof of Proposition 4.1:** The value of a JV is  $V_J(p_t)$  and the investment cost  $I_J$ . If the JV investment is valued at zero at the entry point, it must be the case that  $V_J(p_E) - I_J = 0$ , and if it is valued at zero at the exit point, it must be the case that  $V_J(p_B) = 0$ . Using the general expression for  $V_J(p)$ , we find the system:

$$Ap_E^{\lambda_1} + Bp_E^{\lambda_2} = -\frac{p_E q}{r - \mu} + \frac{q^2}{2v_J} \frac{1}{r} + I_J \quad (4A.1)$$

$$Ap_B^{\lambda_1} + Bp_B^{\lambda_2} = -\frac{p_B q}{r - \mu} + \frac{q^2}{2v_J} \frac{1}{r}. \quad (4A.2)$$

Using the fact that capacity is set at the entry trigger so that  $q = \frac{p_E}{v_J} \frac{r}{r - \mu}$ , we can solve for  $A$  and  $B$ , and the solution is the right-hand side of the equation in Proposition 4.1 (after multiplying by  $\frac{rv_J}{(r - \mu)^2}$ ).

Next, we use the fact that, at the barrier points, the value function must have zero drift, which yields the system:

$$\lambda_1 Ap_E^{\lambda_1 - 1} + \lambda_2 Bp_E^{\lambda_2 - 1} = -\frac{q}{r - \mu} \quad (4A.3)$$

$$\lambda_1 Ap_B^{\lambda_1 - 1} + \lambda_2 Bp_B^{\lambda_2 - 1} = -\frac{q}{r - \mu}, \quad (4A.4)$$

which again can be solved with respect to  $A$  and  $B$ , and the solution is the left-hand side of the equation in Proposition 4.1 (after multiplying the first row by  $\frac{rv_J p_E}{(r - \mu)^2}$  and the second row by  $\frac{rv_J p_B}{(r - \mu)^2}$ ).

**Proof of Proposition 4.2:** The proof is identical to the proof of Proposition 4.1, except we use the value function  $V_S(p)$  instead of  $V_J(p)$ , with the optimal output  $q_t^* = \frac{p}{v_S}$ .

**Proof of Proposition 4.3:** Here, we wish to impose the conditions in Propositions 4.1 and 4.2 at the same time, for given entry and exit prices  $p_E$  and  $p_B$ . We rewrite the left-hand side in Proposition 4.1 as:

$$\begin{aligned}
\begin{pmatrix} \lambda_1 p_E^{\lambda_1} & \lambda_2 p_E^{\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} p_E^2 \\ p_B p_E \end{pmatrix} &= \begin{pmatrix} \lambda_1 p_E^{\lambda_1} & \lambda_2 p_E^{\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \left( \begin{pmatrix} p_E^2 \\ p_B p_E \end{pmatrix} + \begin{pmatrix} 0 \\ p_B^2 - p_E^2 \end{pmatrix} \right) \\
&= \begin{pmatrix} \lambda_1 p_E^{\lambda_1} & \lambda_2 p_E^{\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} p_E^2 \\ p_B^2 \end{pmatrix} \\
&\quad + \begin{pmatrix} \lambda_1 p_E^{\lambda_1} & \lambda_2 p_E^{\lambda_2} \\ \lambda_1 p_B^{\lambda_1} & \lambda_2 p_B^{\lambda_2} \end{pmatrix}^{-1} \begin{pmatrix} 0 \\ p_E p_B - p_B^2 \end{pmatrix}. \tag{4A.5}
\end{aligned}$$

Now, putting the second term above to the right-hand side in Proposition 4.1, we find identical left-hand sides in Propositions 4.1 and 4.2. Then, making the right-hand sides identical also yields Proposition 4.3.

**Proof of Proposition 4.4:** Case of JVs: The welfare flow is  $wq$ , and since  $q = \frac{p_E}{v_J} \frac{r}{r-\mu}$ , the flow is  $\frac{p_E}{v_J} \frac{r}{r-\mu} w$ . The general form of the welfare arising from this flow is, therefore,  $W_J(p_t) = Ap_t^{\lambda_1} + Bp_t^{\lambda_2} + \frac{w}{v_J} \frac{p_E}{r-\mu}$  for constants  $A$  and  $B$ . We know that the welfare must have zero drift at the upper boundary point  $p_E$ , which implies that  $\lambda_1 A p_E^{\lambda_1-1} + \lambda_2 B p_E^{\lambda_2-1} = 0$ . At the lower boundary point  $p_B$ , the drift must be positive, reflecting the possibility that the investment is part of the exit flow of capacity needed to support the price boundary  $p_B$ . The exit rate from the industry at the lower boundary point is  $\eta$ , which can be interpreted as the exit flow that is necessary to support the price at the lower boundary point even though there may be negative exogenous demand shocks. Therefore, the boundary condition at the

barrier  $p_B$  is as follows:

$$\lambda_1 A p_B^{\lambda_1-1} + \lambda_2 B p_B^{\lambda_2-1} = \frac{\eta}{p_B} \left( A p_B^{\lambda_1} + B p_B^{\lambda_2} + \frac{w}{v_J} \frac{p_E}{r - \mu} \right). \quad (4A.6)$$

The details of this derivation can be found in Fries *et al.* (1997). Multiplying the boundary condition at  $p_E$  by the price  $p_E$ , and the boundary condition at  $p_B$  by the price  $p_B$  and rearranging, we find the system in the first part of Proposition 4.4.

Now, doing the same for the case of a WOS, we find the zero drift condition at  $p_E$  becomes  $\lambda_1 A p_E^{\lambda_1-1} + \lambda_2 B p_E^{\lambda_2-1} + \frac{w}{v_S} \frac{1}{r - \mu} = 0$ , and the positive drift condition at  $p_B$  is:

$$\lambda_1 A p_B^{\lambda_1-1} + \lambda_2 B p_B^{\lambda_2-1} + \frac{w}{v_S} \frac{1}{r - \mu} = \frac{\eta}{p_B} \left( A p_B^{\lambda_1} + B p_B^{\lambda_2} + \frac{w}{v_S} \frac{p_B}{r - \mu} \right). \quad (4A.7)$$

Multiplying the first condition by  $p_E$ , and the second by  $p_B$  and rearranging, we find the system in the second part of Proposition 4.4.

**Proof of Proposition 4.5:** Using the principles derived in Chapter 2, the optimal subsidy is exactly equal to the difference between the value of the investment opportunity, which equals zero in the case of competitive industries, and the value of the investment. It follows that for an  $\alpha$  stake in the firm, the subsidy for a JV equals  $-\alpha(V_J(p) - I_J)$ . Additionally, for a WOS, the subsidy equals  $-(V_S(p) - I_S)$ .

**Proof of Proposition 4.6:** The value of the welfare of unsubsidised entry, prior to it actually happening at the entry price  $p_E$ , takes the general form  $A p_t^{\lambda_1} + B p_t^{\lambda_2}$ . We know that, at the entry point, it takes the value of the actual welfare, which is  $W_J(p_E)$  in the case of a JV and  $W_S(p_E)$  in the case of a WOS. We also know that, at the exit point, it must

have zero drift, so that  $\lambda_1 p_B^{\lambda_1-1} + \lambda_2 p_B^{\lambda_2-1} = 0$ . This forms two systems that determine the coefficients  $A$  and  $B$ , and these systems are given in the expressions in Proposition 4.6. The welfare from unsubsidised entry must be the maximum of these, as the firm is indifferent between the mode of entry as long as it is competitive.

**Proof of Proposition 4.7:** Take the case of a JV first. The value of the option to grant an investment subsidy takes the general form  $Ap_t^{\lambda_1} + Bp_t^{\lambda_2}$ . At the lower barrier point  $p_B$ , this value must have zero drift, and at the subsidy trigger point  $p_J^{**}$ , it must smooth paste into the welfare flow  $W_J(p_J^{**}) - K_J(p_J^{**}) - \bar{W}(p_J^{**})$ . Therefore, we can identify two conditions involving the derivative of  $Ap_t^{\lambda_1} + Bp_t^{\lambda_2}$ :

$$\begin{pmatrix} \lambda_1 p_J^{**\lambda_1-1} & \lambda_2 p_J^{**\lambda_2-1} \\ \lambda_1 p_B^{\lambda_1-1} & \lambda_2 p_B^{\lambda_2-1} \end{pmatrix} \begin{pmatrix} A \\ B \end{pmatrix} = \begin{pmatrix} \frac{d}{dp} W(p_J^{**}) - K_J(p_J^{**}) - \bar{W}(p_J^{**}) \\ 0 \end{pmatrix}. \quad (4A.8)$$

The quantity  $\bar{W}(p_J^{**})$  can be identified from Proposition 4.6. The quantity  $W_J(p_J^{**})$  can be identified from Proposition 4.4 (recognising that with subsidised entry, the host country takes the stake  $(1 - \alpha)(V_J(p_J^{**}) - I_J)$ , which together with the subsidy  $-K(p_J^{**}) = \alpha(V_J(p_J^{**}) - I_J)$  adds up to  $V_J(p_J^{**}) - I_J$ . Finally,  $V_J(p_J^{**})$  can be identified from Proposition 4.1. Putting all of this together in the value-matching condition  $Ap_J^{**\lambda_1} + Bp_J^{**\lambda_2} = W_J(p_J^{**}) - K_J(p_J^{**}) - \bar{W}(p_J^{**})$ , we find the condition in Proposition 4.7.

**Proof of Proposition 4.8:** Repeating the procedure in the proof of Proposition 4.7, substituting  $p_S^{**}$  for  $p_J^{**}$ ,  $K_S(p_S^{**})$  for  $K_J(p_J^{**})$ ,  $V_S(p_S^{**})$  for  $V_J(p_J^{**})$ , and  $\Xi_S$  for  $\Xi_J$ , the result is obtained.

## 4.7 Guide to Notation

The table below lists the notation used in this chapter in order of appearance in the text.

Notation	Interpretation
$p_t$	Market price of a good at time $t$
$x_t$	State variable describing random demand shocks
$D(q_t)$	Inverse demand function for industry output
$Q_t$	Aggregate quantity decisions of the firms producing a good
$q_t$	Units of a good produced at time $t$
$r$	Risk-free interest rate
$M_t^+$	Stochastic regulator process that applies at the entry point $p_E$
$M_t^-$	Stochastic regulator process that applies at the entry point $p_B$
$p_E$	Market price for potential firms to enter the industry
$p_B$	Market price for existing firms to exit the industry
$I_J$	Investment cost for a JV
$q$	Constant production
$V_J(p_t q)$	Value of the future discounted profits for a JV when production flow, $q_t$ , is kept constant at $q$
$\frac{v_J}{2}$	Unit variable cost to produce a good for a JV
$q^*$	Optimal constant production for a JV

---

$V_J(p_t q^*)$	Value of the future discounted profits for a JV when production flow, $q_t$ , is kept constant at $q^*$
$I_S$	Investment cost for a WOS
$\frac{v_S}{2}$	Unit variable cost to produce a good for a WOS
$f$	Fixed cost of production for a WOS
$q_t^*$	Optimal variable production for a WOS
$V_S(p_t q_t^*)$	Value of the future discounted profits for a WOS when the good is produced at $q_t^*$
$I$	Investment cost for both modes of entry when $I_J = I_S$ .
$V_J(p_t)$	Value of the investment (firm) for a JV
$V_S(p_t)$	Value of the investment (firm) for a WOS
$w$	Welfare flow per unit of output
$W_J(p_t)$	Welfare from unsubsidised entry in the form of a JV
$W_S(p_t)$	Welfare from unsubsidised entry in the form of a WOS
$\eta$	Exit rate from the industry at the exit trigger point that is necessary to support the price at the lower boundary point
$p$	Price level at which the subsidy is offered
$K_J(p_t)$	Optimal subsidy package for a JV
$\alpha$	Stake of the firm in the JV
$K_S(p_t)$	Optimal subsidy package for a WOS
$\bar{W}_J(p)$	Welfare from unsubsidised entry before it happens in the case of a JV

---

---

$\bar{W}_S(p)$	Welfare from unsubsidised entry before it happens in the case of a WOS
----------------	--

$\bar{W}(p)$	Maximum welfare from unsubsidised entry of a host country
--------------	---

$p_J^{**}$	Optimal subsidy trigger for a JV
------------	----------------------------------

$p_S^{**}$	Optimal subsidy trigger for a WOS
------------	-----------------------------------

---

# Chapter 5

## Conclusions

We have studied how a host country can influence the firm's investment decisions of timing and choice of entry mode using investment incentives. The main contributions lie in three areas. First, the thesis presents specific predictions about the form and timing of an optimal investment subsidy package under various assumptions about first-mover advantages among the firms accepting investment subsidies and among the countries offering investment subsidies. Second, the thesis presents specific predictions about how to target the mode of entry when offering an investment subsidy, where the primary choice is between a JV arrangement in which the firm must give up some operational flexibility in the arrangement and a WOS in which the firm retains full operational flexibility. Finally, the thesis presents specific predictions about how to target the mode of entry when offering an investment subsidy for investment into competitive industries.

In Chapter 2, we study the design of subsidy packages by assuming that the host country can affect the firm's investment timing decision through adjusting the value of the subsidy package. We derive the optimal subsidy package and find that it always compensates the firm for giving up the investment opportunity and making the investment at the host country's



desired timing. Neither the firm nor the host country should be able to extract rent from the subsidy package. Our finding is contrary to the findings of Pennings (2000, 2005) and Yu *et al.* (2007). We evaluate the incremental welfare benefits and costs associated with the subsidy package and find the optimal timing for the host country to provide it. We also study the effect of preemption risk on the timing of investment and the optimal subsidy package. We analyse two cases in which firms are competing to invest in a single country and when host countries are competing to attract an investment to their own locations. We find that preemption risk in the market for investment (i.e., the former case) leads to industries where there are first-mover advantages in the investment process that are more likely to attract FDI subsidy than other industries. We also find that investments that create a large welfare benefit relative to the amortised investment cost are also attractive targets for FDI subsidy. Finally, we find that preemption risk in the market for subsidy (i.e., the latter case) leads to industries where there are first-mover advantages in offering subsidies that are more likely to attract FDI subsidy than other industries.

Our analysis can be applied in many other situations. In the introduction, we mention the example of subsidy to promote investments in a switch from traditional to green technology. Many of the issues that arise in this area are similar to the issues that arise in the FDI market, and we can transfer the results we obtain for FDI directly.

In Chapter 3, we analyse the timing of investment and the choice of entry modes simultaneously and compare the entry modes of a JV and WOS. We confirm that the choice of entry modes will affect the value of the investment project and further affect the timing of investment.

We find that when there is no subsidy offered by the host country, a WOS is always preferred to a JV by the firm from a commercial point of view, while a JV is preferred by

the host country from a social welfare point of view. When the subsidy is offered, we find that a WOS is more attractive to the host country. The host country has to subsidise the foreign firm for its best outside option, which, in our case, is the option to invest in a WOS. The investment in the form of a JV needs to be subsidised more than the investment in the form of a WOS. Therefore, a WOS is found to be more attractive than a JV.

In summary, no matter whether the subsidy is offered or not, we find that a WOS will always be more attractive than a JV. A JV will be preferred only if some definable benefits from the arrangement can be found for the host country, for example, knowledge transfer benefits.

In Chapter 4, we introduce product market competition into our analysis. When firms can enter and exit the industry freely, the process of the output price becomes a doubly absorbing barrier process. The upper barrier coincides with the entry trigger point and the lower barrier coincides with the exit trigger point. When no subsidy is offered, the firms must have the same investment and disinvestment triggers so that both JVs and WOS are equally competitive. This condition imposes some constraints on the cost structure of the firms. It is necessary for a WOS to operate with a fixed cost that a JV does not have.

The welfare effects of unsubsidised entry are not the same. We find by numerical evaluation that when the market price is low, the welfare effect for a WOS is lower than that for a JV, and when the market price is high, the welfare effect of unsubsidised entry is greater when the mode of entry is a WOS than when it is a JV. This is owing to the operational inflexibility of a JV.

When subsidy is offered, we look at the optimal subsidy, the optimal timing of subsidy given the mode of entry, and the optimal mode of entry for the subsidy. We examine the empirical implications by assigning values to the variables. Again, we find that a WOS is

more attractive to the host country. The main conclusion from Chapter 3 is that a subsidy should favour the most operationally efficient enterprise. We add to this in this chapter by studying the subsidy of investments in competitive industries – where operational efficiency is not really well defined, as we make the assumption that both modes of entry are equally competitive. However, still we find that the subsidy should favour the most operationally flexible mode of entry.

# References

- Agliardi, E. and L. Sereno, 2012, On the optimal timing of switching from non-renewable to renewable resources: dirty vs clean energy sources and the relative efficiency of generators, Quaderni DSE Working Paper No. 855, available at [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2180832](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2180832)
- Albornoz, F., G. Corcos, and T. Kendall, 2009, Subsidy competition and the mode of FDI, *Regional Science and Urban Economics* **39**, 489-501.
- Aliber, R. Z., 1970, A theory of direct foreign investment, *International Corporation*, 17-34.
- Amram, M. and N. Kulatilaka, 1999, *Real options*. Harvard Business School Press, Cambridge, Mass.
- Asano, T., 2010, Optimal tax policy and foreign direct investment under ambiguity, *Journal of Macroeconomics* **32**, 185-200.
- Besley, T. and P. Seabright, 1999, The effects and policy implications of state aids to industry: An economic analysis, *Economic Policy* **28**, 13-42.
- Bird, R.M., 2000, Tax incentives for investment in developing countries, in: G. Perry, J. Whalley, and G. McMahon (eds.), *Fiscal Reform and Structural Change in Developing*

- Countries Vol. 1, McMillan Press, 201-221.
- Black, D. and W. Hoyt, 1989, Bidding for firms, *American Economic Review* **79**, 1249-1256.
- Blomström, M., A. Kokko, and M. Zejan, 2000, *Foreign direct investment: Firm and host country strategies*, Macmillan, Basingstoke.
- Bloom, N., R. Griffith, and J. Van Reenen, 2002, Do R&D tax credits work? Evidence from a panel of countries 1979-1997, *Journal of Public Economics* **85**, 1-31.
- Bond, E. W., and L. Samuelson, 1986, Tax holidays as signals, *American Economic Review* **76**, 820-826.
- Boyer, M., P. Lasserre, T. Mariotti, and M. Moreaux, 2004, Preemption and rent dissipation under price competition, *International Journal of Industrial Organization* **22**, 309-328.
- Boyle, P. P., 1977, Options: A Monte Carlo approach, *Journal of Financial Economics* **4**, 323-338.
- Brennan, M. J. and E. S. Schwartz, 1984, Optimal financial policy and firm valuation, *Journal of Finance* **39**, 593-607.
- Brennan, M. J. and E. S. Schwartz, 1985, Evaluating natural resource investments, *Journal of Business* **58**, 135-157.
- Brouthers, L. E., K. D. Brouthers, and S. Werner, 2000, Perceived environmental uncertainty, entry mode choice and satisfaction with EC-MNC performance, *British Journal of Management* **11**, 183-195.

- Brouthers, L. E., K. D. Brouthers, and S. Werner, 2002, Industrial sector, perceived environmental uncertainty and entry mode strategy, *Journal of Business Research* **55**, 495-507.
- Buckley, P. J. and M. Casson, 1981, The optimal timing of a foreign direct investment, *The Economic Journal* **91**, 75-87.
- Buckley, P. J. and M. C. Casson, 1998, Analyzing foreign market entry strategies: Extending the internalization approach, *Journal of International Business Studies* **29**, 539-561.
- Canabal, A. and G.O. White III, 2008, Entry mode research: Past and future, *International Business Review* **17**, 267-284.
- Carr, P., 1988, The valuation of sequential exchange opportunities, *Journal of Finance* **43**, 1235-1256.
- Casson, M., 1994, Internationalization as a learning process: A model of corporate growth and geographical diversification, In V. N. Balasubramanyam and D. Sapsford, editors, *The economics of international investment*, Edward Elgar, Aldershot.
- Chen, S. F. S. and J. F. Hennart, 2002, Japanese investors' choice of joint ventures versus wholly-owned subsidiaries in the US: The role of market barriers and firm capabilities, *Journal of International Business Studies* **33**, 1-18.
- Chevalier-Roignant, B., C. M. Flath, A. Huchzermeier, and L. Trigeorgis, 2011, Strategic investment under uncertainty: A synthesis, *European Journal of Operational Research* **215**, 639-650.
- Chi, T., 2000, Option to acquire or divest a joint venture, *Strategic Management Journal* **21**, 665-687.

- Chi, T. and D. J. McGuire, 1996, Collaborative ventures and value of learning: Integrating the transaction cost and strategic option perspectives on the choice of market entry modes, *Journal of International Business Studies* **27**, 285-307.
- Chi, T. and A. Seth, 2009, A dynamic model of the choice of mode for exploiting complementary capabilities, *Journal of International Business Studies* **40**, 365-387.
- Chor, D., 2009, Subsidies for FDI: Implications from a Model with Heterogeneous Firms, *Journal of International Economics* **78**, 113-125.
- Coase, R.H., 1960, The Problem of Social Cost, *Journal of Law and Economics* **3**, 1-44.
- Collan, M., R. Fullér, and J. Mezei, 2009, A fuzzy pay-off method for real option valuation, *Advances in Decision Sciences* **2009**.
- Cummins, J. G., K. A. Hassett, and R. G. Hubbard, 1996, Tax reforms and investment: A cross-country comparison, *Journal of Public Economics*, **62**, 237-273.
- Danielova, A. and S. Sarkar, 2011, The Effect of Leverage on the Tax-Cut versus Investment-Subsidy Argument, *Review of Financial Economics* **20**, 123-129.
- Davis, P. S., A. B. Desai, and J. D. Francis, 2000, Mode of international entry: An isomorphism perspective, *Journal of International Business Studies* **31**, 239-258.
- Devereux, M. P. and R. Griffith, 2002, The impact of corporate taxation on the location of capital: A review, *Swedish Economic Policy Review* **9**, 79-106.
- Dixit, A., 1989, Entry and exit decisions under uncertainty, *Journal of Political Economy*

**97**, 620-638.

Dixit, A. K., 1993, *The art of smooth pasting*. Routledge, London and New York.

Dixit, A. K. and R. S. Pindyck, 1994, *Investment under uncertainty*. Princeton University Press, Princeton.

Dixit, A. K. and R. S. Pindyck, 1995, The options approach to capital investment, *Harvard Business Review* **73**, 105-115.

De Mooij, R. A. and S. Ederveen, 2003, Taxation and foreign direct investment: A synthesis of empirical research, *International Tax and Public Finance* **10**, 673-693.

Doyle, M., 2010, Informational externalities, strategic delay, and optimal investment subsidies, *Canadian Journal of Economics* **43**, 941-966.

Dunning, J. H., 1988a, The eclectic paradigm of international production: A restatement and some possible extensions, *Journal of International Business Studies* **19**, 1-31.

Dunning, J. H., 1993, *Multinational enterprise and the global economy*. Addison-Wesley, UK.

Dunning, J. H. and A. M. Rugman, 1985, The influence of Hymer's dissertation on the theory of foreign direct investment, *American Economic Review* **75**, 228-232.

Dutz, M. A. and S. Sharma, 2012, Green growth, technology and innovation, World Bank Policy Research Working Paper No. 5932. Available at <http://ssrn.com/abstract=1980586>.

Erramilli, M. K. and D. E. D'Souza, 1993, Venturing into foreign markets: The case of the small service firm, *Entrepreneurship Theory and Practice* **17**, 29-29.



- Erramilli, M. K., S. Agarwal, and C. S. Dev, 2002, Choice between non-equity entry modes: an organizational capability perspective, *Journal of International Business Studies* **33**, 223-242.
- Fries, S., M. Miller, and W. Perraudin, 1997, Debt in industry equilibrium, *Review of Financial Studies* **10**, 39-67.
- Fumagalli, C., 2003, On the welfare effects of competition for foreign direct investments, *European Economic Review* **47**, 963-983.
- Gamba, A., 2003, Real options valuation: A Monte Carlo approach. Faculty of Management, University of Calgary WP, (2002/3).
- Globerman, S. and D. M. Shapiro, 1999, The impact of government policies on foreign direct investment: The Canadian experience, *Journal of International Business Studies* **30**, 513-532.
- Grenadier, S. R., 1996, The strategic exercise of options: Development cascades and overbuilding in real estate markets, *Journal of Finance* **51**, 1653-1679.
- Grossmann, V., T. Steger, and T. Trimborn, 2013, Dynamically optimal R&D subsidization, *Journal of Economic Dynamics and Control* **37**, 516-534.
- Hallén, L. and F. Wiedersheim-Paul, 1979, Psychic distance and buyer-seller interaction, *Organisasjon, Marked og Samfunn* **16**, 308-325.
- Harrison, J.M., 1985, *Brownian Motion and Stochastic Flow Systems*, Krieger Publishing Company, Malabar, Florida.

- Hassett, K. A. and G. E. Metcalf, 1999, Investment with uncertain tax policy: Does random tax policy discourage investment, *Economic Journal* **109**, 372-393.
- Henisz, W. J., 2000, The institutional environment for multinational investment, *Journal of Law, Economics, and Organization* **16**, 334-364.
- Hennart, J. F., 1989, Can the 'new forms of investment' substitute for the 'old forms'? A transaction costs perspective, *Journal of International Business Studies* **20**, 211-234.
- Hines Jr, J. R., 1999, Lessons from behavioral responses to international taxation, *National Tax Journal* **52**, 305-22.
- Hodder, J. E. and H. E. Riggs, 1985, Pitfalls in evaluating risky projects, *Harvard Business Review* **63**, 128-135.
- Huisman, K. J. and P. M. Kort, 1999, Effects of strategic interactions on the option value of waiting. CentER Discussion Paper 9992, University of Tilburg, Center, Tilburg, The Netherlands.
- Klemm, A., 2009, Causes, benefits, and risks of business tax incentives, IMF Working Papers, International Monetary Fund 09/21, International Monetary Fund.
- Klemm, A. and S. Van Parys, 2009, Empirical evidence on the effects of tax incentives, IMF Working Papers, International Monetary Fund 09/136, International Monetary Fund.
- Klemperer, P., 1986, Markets with consumer switching costs, PhD thesis, Graduate School of Business, Stanford University.

- Kogut, B., 1991, Joint ventures and the option to expand and acquire, *Management science* **37**, 19-33.
- Lambrecht, B. and W. Perraudin, 2003, Real options and preemption under incomplete information, *Journal of Economic Dynamics and Control* **27**, 619-643.
- Lambrecht, B. M., 2001, The impact of debt financing on entry and exit in a duopoly, *Review of Financial Studies*, **14**, 765-804.
- Lander, D. M. and G. E. Pinches, 1998, Challenges to the practical implementation of modeling and valuing real options, *Quarterly Review of Economics and Finance* **38**, 537-567.
- Leahy, D. and J. P. Neary, 2009, Multilateral subsidy games, *Economic Theory* **41**, 41-66.
- Leahy, J. V., 1993, Investment in competitive equilibrium: The optimality of myopic behavior, *Quarterly Journal of Economics* **108**, 1105-1133.
- Leland, H. E., 1994, Corporate debt value, bond covenants, and optimal capital structure, *Journal of Finance* **49**, 1213-1252.
- Leland, H. E. and K. B. Toft, 1996, Optimal capital structure, endogenous bankruptcy, and the term structure of credit spreads, *Journal of Finance* **51**, 987-1019.
- Li, J. and A. M. Rugman, 2007, Real options and the theory of foreign direct investment, *International Business Review* **16**, 687-712.
- Lieberman, M. B. and D. B. Montgomery, 1988, First-Mover Advantages, *Strategic Management Journal* **9**, 41-58.

- Luehrman, T. A., 1998, Investment opportunities as real options: getting started on the numbers, *Harvard Business Review* **76**, 51-66.
- Lu, J. W., 2002, Intra- and inter-organizational imitative behavior: Institutional influences on Japanese firms' entry mode choice, *Journal of International Business Studies* **33**, 19-37.
- Luo, Y., 1996, Evaluating the performance of strategic alliances in China, *Long Range Planning* **29**, 534-542.
- MacKie-Mason, J. K., 1990, Some nonlinear tax effects on asset values and investment decisions under uncertainty, *Journal of Public Economics* **42**, 301-328.
- Main, O. W., 1955, *The Canadian Nickel Industry*, University of Toronto Press, Toronto.
- Mason, R. and H. Weeds, 2010, Investment, uncertainty and pre-emption, *International Journal of Industrial Organization* **28**, 278-287.
- Mathews, S., V. Datar, and B. Johnson, 2007, A practical method for valuing real options: The Boeing approach, *Journal of Applied Corporate Finance* **19**, 95-104.
- Mauer, D. C. and A. J. Triantis, 1994, Interactions of corporate financing and investment decisions: A dynamic framework, *Journal of Finance* **49**, 1253-1277.
- Mello, A. S. and J. E. Parsons, 1992, Measuring the agency cost of debt, *Journal of Finance* **47**, 1887-1904.
- Meyer, K. E. and H. V. Nguyen, 2005, Foreign investment strategies and sub-national institutions in emerging markets: Evidence from Vietnam, *Journal of Management Studies*, **42**, 63-93.

- Meyer, K. E., S. Estrin, S. K. Bhaumik, and M. W. Peng, 2009, Institutions, resources, and entry strategies in emerging economies, *Strategic Management Journal* **30**, 61-80.
- McDonald, R. L. and D. R. Siegel, 1985, Investment and the valuation of firms when there is an option to shut down, *International Economic Review* **26**, 331-349.
- McDonald, R. and D. Siegel, 1986, The value of waiting to invest, *Quarterly Journal of Economics* **101**, 707-728.
- Miao, J., 2005, Optimal Capital Structure and Industry Dynamics, *Journal of Finance* **60**, 2621-2659.
- Miller, K.D., 1993, Industry and country effects on managers' perceptions of environmental uncertainties, *Journal of International Business Studies* **24**, 693-714.
- Miltersen, K. R., and E. S. Schwartz, 2004, R&D investments with competitive interactions, *Review of Finance* **8**, 355-401.
- Mintz, J.M., 1990, Corporate tax holidays and investment, *World Bank Economic Review* **4**, 81-102.
- Morisset, J. and N. Pirnia, 2000, *How tax policy and incentives affect foreign direct investment: A review*, **Vol. 2509**, World Bank Publications.
- Murto, P, 2004, Exit in duopoly under uncertainty, *RAND Journal of Economics* **35**, 111-127.
- Myers, S. C., 1977, Determinants of corporate borrowing, *Journal of financial economics* **5**,

147-175.

Myers, S. C., 1984, The capital structure puzzle, *Journal of Finance* **39**, 574-592.

Nam, C. W. and D.M. Radulescu, 2004, Types of Tax Concessions for Attracting Foreign Direct Investment in Free Economic Zones, [ssrn.com/abstract=534707](http://ssrn.com/abstract=534707).

Pan, Y. and P. S. Chi, 1999, Financial performance and survival of multinational corporations in China, *Strategic Management Journal* **20**, 359-374.

Pawlina, G. and P. M. Kort, 2006, Real options in an asymmetric duopoly: Who benefits from your competitive disadvantage? *Journal of Economics & Management Strategy* **15**, 1-35.

Peng M. W., 2008, *Global Business*, South-Western College Publishing, Cincinnati, OH.

Pennings, E., 2000, Taxes and Stimuli of Investment Under Uncertainty, *European Economic Review* **44**, 383-391.

Pennings, E., 2005, How to Maximize domestic benefits from foreign investments: The effect of irreversibility and uncertainty, *Journal of Economic Dynamics and Control* **29**, 873-889.

Pennings, E. and L. Sleuwaegen, 2004, The choice and timing of foreign direct investment under uncertainty, *Economic Modelling* **21**, 1101-1115.

Pennings, E. and O. Lint, 1997, The option value of advanced R&D, *European Journal of Operational Research* **103**, 83-94.

- Perkins, S., R. Morck, and B. Yeung, 2008, Innocents Abroad: The Hazards of International Joint Ventures with Pyramidal Group Firms, [ssrn.com/abstract=1097265](http://ssrn.com/abstract=1097265).
- Pindyck, R. S., 1991, Irreversibility, uncertainty, and investment, *Journal of Economic Literature* **29**, 1110-1148.
- Prescott, E. and M. Visscher., 1977, Sequential location among firms with foresight, *Bell Journal of Economics*, 378–393.
- Raff, H., M. J. Ryan, and F. Staehler, 2006, Asset ownership and foreign-market entry, [ssrn.com/abstract=892737](http://ssrn.com/abstract=892737).
- Rai, A. S. and T. Sjöström, 2001, Grants vs. Investment Subsidies, Working Paper No. 84, Center for International Development, Harvard University, December 2001.
- Rise, A. and J. Trout, 1986, *Marketing Warfare*, McGraw-Hill, New York.
- Rivoli, P. and E. Salorio, 1996, Foreign direct investment and investment under uncertainty, *Journal of International Business Studies* **27**, 335-357.
- Rodrik, D., 1991, Policy uncertainty and private investment in developing countries, *Journal of Development Economics* **36**, 229-242.
- Ross, S. A., 1978, A simple approach to the valuation of risky streams, *Journal of Business* **51**, 453-475.
- Ross, S. A., 1995, Uses, abuses, and alternatives to the net-present-value rule, *Financial Management* **24**, 96-102.

- Sarkar, S., 2012, Attracting private investment: Tax reduction, investment subsidy, or both? *Economic Modelling* **29**, 1780-1785.
- Schmalensee, R., 1981, Economics of scale and barriers to entry, *Journal of Political Economy*, 1228–1238.
- Shapiro, D. and S. Globerman, 2001, National infrastructure and foreign direct investment, Manuscript, Simon Fraser University.
- Shah, A. (ed.), 2005, *Fiscal Incentives for Investment and Innovation*, Oxford University Press, Oxford.
- Sharma, V. M. and M. K. Erramilli, 2004, Resource-based explanation of entry mode choice, *Journal of Marketing Theory and Practice* **12**, 1-18.
- Smets, F., 1991, Exporting versus FDI: The effect of uncertainty, irreversibilities and strategic interactions, Working Paper, Yale University.
- Smets, F., 1993, Essays on foreign direct investment, PhD thesis, Yale University.
- Smit, H. T. and L. A. Ankum, 1993, A real options and game-theoretic approach to corporate investment strategy under competition, *Financial Management* **22**, 241-250.
- Sparla, T., 2004, Closure options in a duopoly with strong strategic externalities, *Zeitschrift für Betriebswirtschaft* **67**, 125-155.
- Spence, A. M., 1981, The learning curve and competition, *Bell Journal of Economics* **12**, 49-70.



- Thomas, K.P., 2007, *Investment incentives. Growing use, uncertain benefits, uneven controls*. Report prepared for Global Subsidies Initiative (GSI) of the International Institute for Sustainable Development (IISD) in Geneva, Switzerland.
- Trigeorgis, L., 1993, The nature of option interactions and the valuation of investments with multiple real options, *Journal of Financial and Quantitative Analysis* **28**, 1–20.
- Trigeorgis, L., 1996, *Real options: Managerial flexibility and strategy in resource allocation*. MIT Press.
- Trigeorgis, L. and S. Manson, 1987, Valuing flexibility as a complex option, *Journal of Finance* **45**, 594-565.
- Vernon, R., 1966, International investment and international trade in the product cycle, *Quarterly Journal of Economics* **80**, 190-207.
- Wang, Q., Z. Xu, and Z. Wu, 2010, An analysis of football player transfer problems based on real options. In *2010 International Conference on Management and Service Science*.
- Weeds, H., 2002, Strategic delay in a real options model of R&D competition, *Review of Economic Studies* **69**, 729-747.
- Werner, S., 2002, Recent developments in international management research: A review of 20 top management journals, *Journal of Management* **28**, 277-305.
- Williamson, O. E., 1979, Transaction-cost economics: The governance of contractual relations, *Journal of law and economics* **22**, 233-261.
- Williamson, O. E., 1985, Assessing contract, *Journal of Law, Economics, and Organization*,

**1**, 177-208.

Yu, Chia-Feng, Ta-Cheng Chang, and Chinn-Ping Fan, 2007, FDI Timing: Entry Cost Subsidy versus Tax Rate Reduction, *Economic Modelling* **24**, 262-271.

Zee, H. H., J. G. Stotsky, and E. Ley, 2002, Tax incentives for business investment: A primer for policy makers in developing countries, *World Development* **30**, 1497-1516.

Zhu, K., and J. Weyant, 2003a, Strategic exercise of real options: Investment decisions in technological systems, *Journal of Systems Science and Systems Engineering* **12**, 257-278.

Zhu, K. and J. Weyant, 2003b, Strategic decisions of new technology adoption under asymmetric information: A game-theoretic model, *Decision sciences* **34**, 643-675.