Essays on investment behavior under uncertainty, deferrability, and strategic interactions

– Delay, preemption, coordination problems, and economic efficiency –

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Abstract

The aim of this dissertation is to analyze the investment behavior of agents under uncertainty, deferrability, and strategic interactions.

When we make some investment decision, it is rare that we can obtain all the necessary information required for making a good decision. Rather, it is usual that we have to make our important and irreversible investment decisions facing various kinds of uncertainty. For example, for an investor planning to invest his or her money in stocks, the future returns from the stocks are uncertain as of the date of the investment. Similarly, for a firm manager who must decide whether to adopt a new technology, the profitability of adopting the new technology is usually quite uncertain. Considering that investment is the act of incurring an immediate cost in the expectation of future rewards, uncertainty is ubiquitous in the investment process.

In general, uncertainty is classified into two types: external uncertainty and strategic uncertainty. External uncertainty is the uncertainty that arises from natural randomness in the external environment. Uncertainty about future weather conditions and uncertainty about the likelihood of the occurrence of a catastrophic disaster within the following few years are typical examples of such external uncertainty. In the case of this type of uncertainty, the degree of uncertainty is external for a decision maker and independent of any agents' strategic behavior. On the other hand, strategic uncertainty arises when we play a game with other self-interested decision makers. Except for a few simple cases where the actions of other agents are perfectly observable or easily predictable, there are many situations in which we face grave uncertainty about past decisions or the prospective behavior of other agents. Differing from the case of external uncertainty, the degree of strategic uncertainty is not necessarily external for a decision maker. Rather, it is influenced by the strategic interactions between agents who individually pursue their

self-interest. Facing various kinds of external and strategic uncertainty, we need to make our significant investment decisions so that ex post regrets upon incurring irreversible investment expenditures can be minimized.

Investment under uncertainty and deferrability

When we have to make our significant investment decisions under uncertainty, whether investment decisions are deferrable or not is an important point. If investment decisions are not deferrable (i.e., we have no option to defer investment decisions), the optimal investment policy for us is to follow the so-called net present value (NPV) investment criterion. According to the standard NPV criterion, we should invest if and only if the expected present value of benefits from the investment exceeds the investment costs. Although there are some technical issues associated with using the NPV criterion in practice, such as the difficulty in correctly estimating the stream of future revenues and the problem in determining an appropriate discount rate, the NPV criterion usually presents an appropriate decision rule under nondeferrability of investment.

If investment decisions are deferrable, however, the traditional NPV investment rule is no longer valid and may result in incorrect decisions. The reason is that the standard NPV investment rule is based on the assumption that investment is a "now or never" decision (i.e., it can be undertaken today or never) and ignores the option value of waiting. If there is deferrability in an investment opportunity, our decision problem is not just to determine whether to undertake an investment project but to choose when to undertake it. Although postponing investment into the future means the loss of current revenues that could be obtained from immediate investment and may bring additional risks of losing all investment opportunities to undertake investment projects in the future, by doing so, we may be able to undertake investment projects under more favorable conditions in the future or may be able to avoid making unnecessary, irreversible expenditures in ultimately unprofitable projects. Therefore, if investment decisions are deferrable, we need to optimally trade off the costs and benefits of waiting under uncertainty. A large recent literature argues that the potential benefits of deferrability are often large and claims that the traditional NPV investment rule overlooks such option value of deferrability.

In Chapter 2 of this dissertation, we analyze the investment behavior of firms under uncertainty, irreversibility, and deferrability. In our dynamic investment model, firms face external uncertainty over the project value and the severity of financial constraints in the future. Individual firms can postpone undertaking their investment projects for more favorable investment conditions, but investment is assumed to be irreversible once implemented. Postponing investment may provide an opportunity to obtain more reliable information, but by doing so, firms may face an additional risk of not being able to obtain external financing in the future. Thus, by optimally trading off the costs and benefits of postponing investment decisions under uncertainty over the project value and the severity of financial constraints in the future, individual firms must determine the optimal time for investment.

According to conventional investment theory based on the net present value (NPV) criterion or the adjusted present value (APV) criterion, the current investments of financially more constrained firms should be smaller than those of less constrained firms with similar investment opportunities. In Chapter 2, we reexamine the theoretical robustness of this monotonic ordering hypothesis in standard investment theory. In particular, we examine whether it is conceivable for a financially more constrained firm to invest more or earlier than a less constrained firm. Through model analysis and by developing a numerical example, we show that it is possible that financially more constrained firms decide to undertake a risky investment project earlier than do less constrained firms with the same investment project. In our model, while financially less constrained firms have an incentive to delay their investment decisions under uncertainty, to preempt further financing risk in the future, financially more constrained firms may engage in more active investment behavior even if they face relatively higher additional financing costs (i.e., have a smaller APV) at the time. Our numerical example demonstrates that a relatively low probability of future financing risk is sufficient to cause such preemptive behavior. In Chapter 2, in extending the model analysis, we also provide some empirical implications for the lively debate over firms' investment-cash flow sensitivities.

Coordination problems and inefficiency

In a highly decentralized economy, there are many situations in which we are forced to play complicated games with other agents. Differing from the case of a perfect competition in which one can behave as a passive price taker and the case of a monopoly in which one faces only a simple single-agent decision problem, the optimal behavior and ultimate payoffs of agents under game situations will depend crucially on the strategic interactions between multiple self-interested agents. In such game situations with strategic interactions, nobody can determine his or her optimal strategy without considering other agents' reactions (except for the case where there is a distinct dominant strategy for agents).

Among various kinds of game situations, coordination games have several distinct features that make them quite interesting and attractive in many areas of economic research. First, in contrast to many noncooperative strategic situations, coordination games do not rest only on conflict between agents. In typical coordination games such as stag-hunt games and speculative attack games, an agent's marginal payoff from taking an action (i.e., going hunting or attacking a currency) increases with the level of the actions of other agents. In other words, there are strategic complementarities among agents' activities in typical coordination games. Next, because of the existence of such strategic complementarities, coordination games typically have self-fulfilling multiple equilibria. Taking the example of stag-hunt games with two strategies (go hunting or stay), two Pareto-ranked pure strategy Nash equilibria can arise: one is the Pareto-superior equilibrium where every individual chooses to go hunting under opportunistic beliefs about others' activities, and the other is the Pareto-inferior equilibrium where every individual chooses to stay under pessimistic beliefs about others' activities. Third, the possibility of Pareto-ranked multiple equilibria in coordination games gives room to address some important policy issues. In fact, many economists have analyzed how socially inefficient coordination failures can be avoided in various situations by using various types of coordination games (e.g., coordination games with poverty traps and bank runs).

While accepting these attractive characteristics of coordination games, the recent literature, however, points out some shortcomings of traditional coordination games. For one thing, while traditional coordination game models are eloquent on how multiple self-fulfilling Nash equilibria can arise in coordination games, in most cases they provide little information regarding which Nash equilibrium actually occurs. Next, the basic assumptions about the information structure in traditional coordination games are simplistic. In traditional coordination games, the payoffs (types) of each agent are assumed to be common knowledge and individual agents face strategic uncertainty only. In other words, traditional coordination games are complete information games and no one faces any external uncertainty. Furthermore, equilibrium multiplicity in traditional coordination games makes conducting rigorous policy analysis and other comparative statics exercises difficult because the effects of marginal changes in the policy variables or other model parameters on equilibrium outcomes cannot be definitely and meaningfully determined under equilibrium multiplicity.

Based on the recognition of these shortcomings in conventional coordination games, the recent literature on global games provides an analytical framework to overcome such drawbacks of traditional coordination games. Global games, pioneered by Carlsson and van Damme (1993) and further extended by Morris and Shin (1998) and others, are incomplete information games in which individual players receive noisy private signals about the underlying payoff-relevant state of nature that is assumed to be unobservable. By introducing some structural uncertainty into the models, the global games approach solves the problem of multiplicity of equilibria under strategic uncertainty and opens the possibility of equilibrium uniqueness. Uniqueness of equilibrium may enable us to conduct rigid policy analysis under more realistic conditions.

In Chapter 3 and Chapter 4 of the dissertation, by employing the global games approach, we analyze the financing and investment behavior of multiple agents under coordination problems and address the associated policy issues. In Chapter 3, we investigate the coordination problem among multiple lenders when their common borrower falls into temporary financial distress. In our model presented in Chapter 3, a coordination problem can arise because the return of a lender from rolling over his or her loan depends crucially on whether other lenders also roll over their loans or not. Developing a financing game with both external and strategic uncertainty, we first show that inefficient early liquidation of a fundamentally solvent project can arise in both multiple equilibria under complete information and a uniquely determined equilibrium under incomplete information as a result of coordination failure among lenders. We then analyze the role and effects of public policies that are designed to prevent inefficient financing from actually occurring. We investigate the effects of two types of public policies: an information policy and a public guarantee program. Our analysis shows that the inefficiencies caused by coordination problems among lenders can be effectively and efficiently removed only when both policies are simultaneously designed and implemented in an appropriate combination. In this chapter, we also address the potential cost of public intervention in coordination problems, focusing particularly on the negative influence on the ex ante effort incentives of agents.

In Chapter 4, we analyze the coordination problems among agents in a more general and extended framework. In this chapter, we develop an investment coordination model in which numerous agents simultaneously and independently determine whether to undertake a risky but potentially more profitable investment project or an alternative investment project with safe but lower returns. We assume that strategic complementarities exist in the payoffs from the risky investment projects, such that the profitability of the risky investment project increases with the level of other agents' activities. In this investment coordination model, we first show that the risk of coordination failure among agents can cause socially low levels of investment and consumption in equilibrium. Then, as in Chapter 3, we investigate the role and effects of public investment policy that is considered to help mitigate possible inefficiency arising from coordination problems among agents. In our model, the size of an implementable public investment policy is determined endogenously. Providing various numerical results, we show that the divisibility of the investment projects, the presence of financial constraints, the productivity of public investment, and the relative size of public and private information precision, as well as the relative size of tax rates imposed on risky investments and safe investments, complexly affect the effects of public investment policy under coordination problems and welfare. In particular, we demonstrate that a public investment policy of a larger size and the availability of more precise information do not necessarily increase welfare.

Strategic investment under information learning

In the coordination games analyzed in Chapter 3 and Chapter 4, agents make their investment decisions simultaneously and independently. The assumption of simultaneous decisions means nondeferrability of actions, which implies that there is no opportunity for agents to learn from other agents' behavior by delaying their investment decisions. Indeed, there are many situations in which simultaneity of decisions and nondeferrability capture the essence of the problem. However, there are also various situations in which agents can move sequentially and have an opportunity to learn from other agents' behavior by taking a wait-and-see strategy. A typical example of such situations is the technology adoption problem under uncertainty. By taking a wait-and-see strategy and observing other firms' adoption behavior, firm managers may be able to obtain additional information about the profitability of a new technology. The problem is that not all firm managers can use such a wait-and-see strategy. Someone must move first without learning. To investigate who moves first and how the remaining agents follow is thus an important issue when analyzing strategic investment behavior under the possibility of information learning.

In Chapter 5, we analyze the technology adoption problem of firms under the possibility of information learning. In our model, relevant information about a new technology is dispersed among multiple firms, and imperfectly and asymmetrically informed firms determine strategically when to adopt the new technology under uncertainty and deferrability. Deriving an equilibrium for the N-firms waiting game under information learning, we show that as compared with the full-information optimum, three characteristic adoption patterns can emerge under imperfect and dispersed information as a result of the optimal behavior of individual firms. First, an economically inefficient initial delay can arise as a result of strategic delay by partially informed firms. In our model, partially informed firms trade off the benefits of early adoption with the benefits of waiting for information to be revealed through the actions of other firms. Under this trade-off, the firm that first adopts a new technology in equilibrium is the firm that has the most precise and optimistic information about the quality of the new technology. The possibility of an initial delay implies that even his or her adoption timing can be delayed as compared with the economically efficient adoption timing under perfect information. Second, a staggered adoption can arise as an equilibrium phenomenon in our model when the valuations about the quality of a new technology are divergent among firms. In this case, multiple firms adopt a new technology sporadically. In our model, such a staggered adoption can arise as a result of information learning among imperfectly and differently informed multiple firms with an opportunity to discretionally defer their adoption timing to learn more precise information. By contrast, an inefficiently early mass adoption can also arise in our model, particularly in the form of herding behavior among firms. In this case, once some firms adopt a new technology, the remaining firms follow them immediately, ignoring their private information. As efficient information learning stops once herding occurs, an inefficiently early mass adoption can arise in our model.

In Chapter 5, we also address the incentive scheme for achieving an economically efficient collective adoption of a new technology under dispersed information. We investigate a simple timing-implementation problem and present a straightforward incentive scheme for attaining an efficient information pooling and thus an economically efficient collective adoption of a new technology under dispersed information.

In the final chapter of the dissertation, we present concluding remarks.