



Reversibility in dynamic coordination problems [☆]

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ABSTRACT

We study a dynamic coordination process in which agents are uncertain about the actions of their fellow agents, and anticipate strategically relevant information. Because of the uncertainty and learning, (ir)reversibility of actions has important strategic consequences. We find that the reversibility option can either enhance or hamper efficient coordination, and we characterize the direction of the effect based solely on simple features of the coordination problem. The analysis is based on the following generalization of the Laplacian property known from static global games: agents at the beginning of the dynamic game act as if they were entirely uninformed about the aggregate play of fellow agents in each stage of the coordination process.

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1. Introduction

An agent at the outset of an economic crisis faces strategic uncertainty. She does not know the future of the economy because she is uncertain how fellow agents perceive the odds of the crisis and hence how they will react. As the crisis unfolds, the agent receives strategically valuable information upon which she may reconsider her earlier decisions. Therefore, her early investment decisions and, at the macroeconomic level, the aggregate actions and the final outcome of the crisis may crucially depend on the *reversibility* of the early actions. The effects of reversibility are complex. On the one hand, reversibility allows agents to react early to crises, effectively alleviating fears of entry. On the other hand, reversibility may lead to panic exit waves that deepen the late stages of crises. The expectation of the panic may exacerbate anticipatory fears.

Our starting observation, that of strategic uncertainty at the outset of crisis, is well formalized in the global games literature.¹ A global game is a static, incomplete information coordination game. Agents receive private signals about an

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¹ The theory of global games was originated by Carlsson and van Damme (1993) and further developed by Morris and Shin (2003).

Table 1
Effect of the reversibility option on the occurrence of coordination failures.

Payoff spillovers		Option to	
Backward	Forward	Exit	Delay
✓	×	More failures	Fewer failures
×	✓	Fewer failures	More failures
×	×	Irrelevance result	

underlying economic fundamental and, in the unique equilibrium, those with signals above a certain threshold invest. Our uncertain agent fearing the crisis corresponds to the threshold type who, being on the boundary between the investing and non-investing types, is uncertain about the aggregate investment. A key to the solution of static global games is the so-called *Laplacian property* which claims that the belief held by the threshold type is very simple: she believes that the aggregate investment is distributed *uniformly* across all feasible investment levels. To emphasize the connection to Laplace's principle of insufficient reason, [Morris and Shin \(2003\)](#) dub such a belief *Laplacian*. In this paper we generalize this Laplacian property for dynamic environments.

Because of their tractability, static global games are often applied even at the cost of suppressing dynamic features of the analyzed problem. For example, [Morris and Shin \(2004\)](#) study debt crises as coordination failures arising among creditors. Treating the early investments of the creditors as exogenous, they allow them to prematurely withdraw their funds in the interim stage of the project. The modeled interaction thus becomes a simultaneous-move game in which investors prefer to withdraw if they believe that too many fellow investors are withdrawing. The authors apply the static global game framework and find investors' panic in the unique equilibrium—a wave of inefficient interim exits. It is thus natural to ask whether the exit option should be provided, and at what cost. Such a question requires a dynamic model with endogenous entry decisions because policies affecting the exit option—the liquidity of investment—will also affect the entry. This paper provides such framework.

We study a dynamic coordination game in which agents decide whether to invest in a project consisting of two stages. At the beginning of the first stage, all agents make a binary investment decision based on their initial private information. During the first stage, agents learn additional private information and they can reverse the initial decision in between the two stages. More precisely, one of the two available actions, investment (risky action) or no investment (safe action), is irreversible and the other is reversible. This induces an option value of the reversible action. We call the reversibility of the risky investment the *exit* option and reversibility of the safe action the *delay* option.

We study the effects of the reversibility option by comparing the equilibria of the dynamic game with that of a benchmark static game without the option. Such a comparison is not straightforward because it has to deal with strategic effects. In non-strategic decision problems, the reversibility option is unambiguously beneficial, as it allows for adjustment to the arriving information. However, in strategic environments, reversibility may lead to fear-driven panic exits or to investment delays. Thus, reversibility may either hamper or enhance coordination on investment.

The value of the option to reverse early action is an endogenous, equilibrium object in our model. Our main technical insight is that it can be partially characterized by the use of *the Laplacian property generalized to dynamic games*. We find that the threshold type at the beginning of the game forms an expectation of the option value as if she had no information about the investment level in the late stage of the project.

Thanks to the generalized Laplacian property, the characterizing of the reversibility effects becomes simple. As the property holds in both the static and dynamic games, we need not worry about the differences in the equilibrium beliefs across the two games and we can evaluate the differences in equilibrium actions based solely on certain simple mechanistic properties of the investment project.

We find that the strategic consequences of the option depend on the intertemporal payoff structure. Agents receive profit for each project stage in which they participate and maximize the total sum of profits. We say that payoffs exhibit *forward spillovers* if production involves inertia, such that the profit in the late stage depends not only on the late but also on the early investment level. Payoffs exhibit *backward spillovers* if the profit in the early stage depends not only on the early but also on the late investment level.² Using this terminology, the effects are as in Table 1: the exit option enhances efficient coordination in projects with no backward spillovers and hampers efficient coordination in projects with no forward spillovers. The delay option has the opposite effects. As a corollary, neither the exit nor the delay option has any effect in projects without both backward and forward spillovers.

We share a focus on the effects of reversibility options on investment decisions with [McDonald and Siegel \(1986\)](#) or [Dixit and Pindyck \(1994\)](#), but we differ in the source of uncertainty. Their work on single-person investment decisions with delay option considers uncertainty coming from exogenous shocks. In our model, uncertainty is endogenous and strategic as the agents are uncertain about others' actions.

Our paper belongs to a booming literature on dynamic global games. One strand of this literature emphasizes the intertemporal tradeoffs of agents facing frictions in an evolving environment ([Burdzy et al., 2001](#); [Levin, 2001](#), or [Chassang, 2010](#)). A second strand studies public learning in a stable environment and emphasizes equilibrium multiplicity induced by

² Backward spillovers arise, for instance, if agents cannot fully exit the project or under schemes which redistribute profits among the investors.

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