Available online at www.sciencedirect.com
ScienceDirect
Journal of Economic Theory 145 (2010) 689–720
JOURNAL OF Economic Theory
www.elsevier.com/locate/jet

Overcoming the coordination problem: Dynamic formation of networks ☆

Jack Ochs [a], In-Uck Park [b,*]

[a] *Department of Economics, University of Pittsburgh, Pittsburgh, PA 15260, USA*
[b] *Department of Economics, University of Bristol, Bristol, BS8 1TN, UK*

Received 24 July 2008; final version received 30 June 2009; accepted 2 November 2009

Available online 3 December 2009

Abstract

We analyze a multi-period entry game among privately informed agents who differ with respect to the number of agents who must enter in order for their own entry to be profitable. In each period agents who have not yet joined decide whether to subscribe to a network. There exists a unique equilibrium that approximates any symmetric equilibrium arbitrarily closely as the discount factor approaches one. This resolves the coordination problem. Ex-post efficiency is necessarily achieved asymptotically as the population size grows large. These results do not hold if subscribers can reverse their decisions without cost.

JEL classification: D82; D85

Keywords: Strategic complementarity; Network externality; Coordination

1. Introduction

Adoption/network externalities arise when complementarities exist across agents in the consumption of certain goods or services. Examples include commodities designed for joint con-

☆ We thank Avinash Dixit, Joe Farrell, Meg Meyer, Kevin Roberts, and Glen Weyl, as well as an Associate Editor and two anonymous referees, for various helpful comments and suggestions, and also the seminar participants at the Universities of Bielefeld, Chemnitz, Exeter, Hitotsubashi, Nuffield College (Oxford), Ohio State, Pittsburgh, Southampton, and Toulouse, and the Far Eastern Meeting of the Econometric Society in Seoul (2004). The usual disclaimer applies. Park thanks the ESRC (UK) for funding this research project under grant RES-000-22-1806.
* Corresponding author. Fax: +44 117 331 0705.
E-mail addresses: jochs@pitt.edu (J. Ochs), i.park@bristol.ac.uk (I.-U. Park).

0022-0531/$ – see front matter
doi:10.1016/j.jet.2009.11.006

sumption or sharing (telephony and data networks), those with indirect scale economies for complementary goods (hardware–software and durable-good servicing), and adoption of innovations and standards where compatibility is valuable.

Due to strategic complementarity, there typically exist multiple, Pareto ranked equilibria in such markets. The worst is a null equilibrium in which no one adopts because no one is ever anticipated to adopt; while at the other end is a "maximum" equilibrium in which a "maximal set of agents" who would adopt when that is what everyone expects to occur, indeed adopt. There may be other equilibria intermediate between these two, sustained by various self-fulfilling expectations. With no outside force present, the particular equilibrium to be realized is indeterminate. This is a well-known coordination problem.

One strand of research has studied inducement schemes as a device to overcome the likelihood of coordination failure in static, simultaneous move entry games. These schemes provide insurance against low adoption or entry rates. Such insurance warrants a sufficient rate of adoption by those who have a low cost of entry, which, in turn, will induce others with higher entry costs to also enter. Dybvig and Spatt [9] and Park [19] devise insurance schemes that will induce certain target equilibria as the unique (symmetric) equilibrium at the minimal expected cost of insurance subsidy. Bagnoli and Lipman [2] study a refund mechanism to induce private contribution to a public project where a sufficient number of people must contribute before the project produces any benefit.

In this paper we analyze the effect of a dynamic adoption process on resolving the coordination problem in the market entry game when agent types are privately and independently drawn from a commonly known distribution. A dynamic adoption process, however, introduces a strategic consideration that is absent in the static game. Individuals who chose to enter early may influence the entry decisions of others who have not yet entered. This creates the possibility that early entrants may launch a domino chain reaction of widespread adoption. However, agents considering early entry will be so motivated only if they expect such a domino chain. Such a domino chain itself relies on a nested sequence of optimistic beliefs of future adopters. At first sight, therefore, it appears that the basic intuition of coordination failure due to multiplicity of self-confirming expectation would continue to prevail in dynamic adoption process. Rather surprisingly, we establish that this is not the case. Specifically, we show that there exists a unique perfect Bayesian equilibrium that approximates any symmetric equilibrium arbitrarily closely as the discount factor approaches one.

In our model, as will be formally described in Section 2, agents' types are ordered by the utility levels agents derive from being a member of the network. Since each member's utility increases as the network gets larger, the higher is the utility an agent derives from the network the lower is the threshold network size for this agent to join profitably. Hence, we say an agent who derives a *higher* utility level from the network has a *lower* type.

First, as a benchmark we analyze the case that agents do not discount the future. Since the timing of action does not matter so long as the final outcome is the same in this case, the exact timing of entry by agents of various types is not pinned down in equilibrium (although the order of entry is). Given that our main interest is on the cases of small yet positive discounting and the agents prefer bringing forward the entry process in these cases, we temporarily impose a stopping rule that if no one entered in some period then no further entry may take place subsequently (this rule makes delaying entry unattractive).

In such equilibria, all agents choose a cutoff strategy in which an agent enters in any period k precisely when his type is no higher than a cutoff level for that period. The cutoff levels are strictly above the lower bound, so entry always occurs with a positive probability. Intuitively,