3 Reciprocity, Proximity and Performance of Research Consortia

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3.1 INTRODUCTION

The Japanese model of publicly funded consortia was adopted in the United States beginning in the 1980s following the relaxation of antitrust restrictions on joint research and development (R&D). A great example of such an effort is Sematech (Semiconductor Manufacturing Technology), a publicly subsidized consortium of 14 semiconductor firms. As we will explain, the economics of consortia has been tackled from several angles including knowledge transfer between the consortium and its members (e.g., see Irwin and Klenow 1996; Link et al 1996; Sakakibara 1997). However, there is no theoretical work that models the transfer of tacit, that is, difficult to codify, knowledge between the member firms and the consortium within a geographical context. This is what we add to the consortium literature in this study. The relatively simple mathematical

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setup provides us with intuition to understand the mechanics behind knowledge transfer among the competing parties, which is the case of the firms located in Silicon Valley.

In the existing literature on consortia, several authors point out the importance of knowledge spillovers between the participant firms. For example, Branstetter and Sakakibara (2000) examine the impact of a large numbers of research consortia, which are sponsored by the American and Japanese governments, on the productivity of the participating firms. The authors find that such productivity is positively correlated with the level of potential spillovers among the consortium participants. In addition, Irwin and Klenow (1996) report that several executives of the participating firms of the Sematech Consortium describe such spillovers as occurring via people-to-people interaction and sending personnel to Austin, where the consortium is located. Hence, in both cases the authors focus on the transfer of tacit knowledge, for which face-to-face meetings are required. In this study, we argue that geographical proximity plays a critical role due to two issues. First, exchange of tacit knowledge requires the transferring firm to train the transferee, for example, by demonstrating the knowledge. Hence, these two parties need to colocate for the transfer to take place. In addition, tacit knowledge is difficult to specify *ex ante*, and it is difficult to verify ex-post whether the promised knowledge is delivered or not. Hence, incentive alignment between the parties becomes an issue. We argue that proximity facilitates the alignment of these incentives as it enables parties to monitor each other's actions. Further, we argue that reciprocal learning among the consortium firms also improves the incentive

alignment between the exchanging parties as it restores incentives to cooperate. If learning is one sided, we argue, the incentive to cooperate would be much weaker. This is a simple application of the reciprocity phenomena in the trust literature, where parties are observed to cheat less in agreements when they receive reciprocity (e.g., see Martin et al 2004).

In particular, in this chapter following the Sematech example, we model a multimember consortium where member firm employees travel to the consortium and engage in meetings to exchange knowledge. As we just explained, we aim to find out how the geographical proximity between the firms and the consortium as well as reciprocal learning among member firms affect the efficiency of knowledge exchange. In doing this, we do not model the research process, but rather concentrate solely on the transfer of knowledge. To the best of our knowledge although knowledge transmission is studied by some others (e.g., Berliant et al, 2000; Cooper 2001; Goyal and Moraga-Gonzalez 2001), the two most relevant features to such exchange—geographical proximity and reciprocal learning—are not modeled within a consortium framework.

Our findings show that when reciprocal learning is significant, individual firms are more likely to contribute to the consortium over time. In addition, knowledge exchange is observed to be more sustainable over larger distances between the firms and the consortium if it is more effective in reducing firm costs.

In the next section, we introduce an infinitely repeated technology trading game, where member firms exchange knowledge by traveling to the consortium. Firms have a choice to passively receive knowledge in the meetings or

reciprocate; both of which decrease the costs of production. Subsequently, we model a symmetric Cournot quantity competition in the product market. In the third section we conclude.

3.2 MODEL

We envisage an N firm symmetrical consortium where firms are located around a circle with diameter d. Each firm is represented by a single employee who receives knowledge every period, and each period he or she has to decide whether to travel to the consortium and if done, whether to truthfully disclose knowledge in bilateral meetings with the other consortium firms. We assume that if, at the end of each period, any firm cheats, the firm, represented by the employee, is expelled from the consortium, and after that, the consortium stays intact. This equilibrium concept is described as *stacked reversion* by Eaton and Eswaran, who claim that it is a better representative of cooperation in coalitions in comparison to Nash reversion.

We assume that traveling to a consortium is costly but that once the employee is at the consortium, bilateral meetings are costless. Firms are assumed to be located evenly around a circle, and they are assumed to be connected to the consortium via a spoke with length $d/2$. In order for each firm to be at another firms' facilities, each has to travel along the spoke to the consortium, incurring a travel cost in the amount of $d/2$, where the unit costs are normalized to a dollar. This is structured to assume away any asymmetries between the member firms, as such is not the focus of this paper.

Let q_i be the output chosen by firm *i* and the total industry output be $Q = \sum_{i=1}^{N} q_i$. The industry demand is given by $P(Q) = a - bQ$. The cost function of each firm *i* is specified as the following:

$$c_i(x) = \alpha - \beta \sum_{i \neq j} x_{ji} - \gamma \sum_{i \neq j} x_{ij} x_{ji}$$

(3.1)

where x_{ji} is firm *j*'s disclosure of its knowledge, which takes the value of (3.1) if firm *j* is truthful; β is the cost-reducing parameter for the unilateral knowledge transfer, and γ is the cost-reducing parameter for reciprocal learning.

If all firms truthfully transfer knowledge, given (3.1), they each have the following cost function:

$$c_i^{cooperate}(x) = \alpha - (\beta + \gamma)(N - 1) \tag{3.2}$$

And given (3.2) in the repeated game, the firm can either cooperate forever or cheat on the sharing agreement. If the firm chooses to cooperate, forever, it gets the following payoff at the equilibrium where δ is the discount factor:

$$\pi_i^{cooperate}(x) = \frac{\left[\frac{[a - \alpha + (\beta + \gamma)(N - 1)]^2}{b(N+1)^2} - \frac{d}{2} \right]}{(1 - \delta)} \tag{3.3}$$

Alternatively, the firm can choose to cheat on the sharing agreement. This can occur in two alternative ways. If the reciprocal learning is sufficiently large, that

is, $\gamma > \frac{\beta}{N-1}$,[1] then the firm would cheat by not traveling to the consortium as, once traveled, it would choose to share its knowledge. If it chooses not to travel, its membership in the consortium would be ended or it would be ostracized from then on, making it no longer accepted as part of the consortium and knowledge exchange. In this case, the firm's payoff will be as follows:

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[1] This is if profits from cooperation are larger than the profits from cheating in the stage game, that is, $\pi^{cooperate} > \pi^{cheat}$ implies $\gamma > \frac{\beta}{N-1}$.

$$\pi_i^{nottravel-cheat}(x) = \frac{\frac{\left[a-\alpha+(\beta+\gamma)(N-1)(N-2)\right]^2}{b(N+1)^2}}{(1-\delta)}$$

(3.4)

If, on the other, hand the reciprocal learning is sufficiently small, that is, if $\gamma < \beta/(N-1)$ then the firm can travel to the consortium and withhold its knowledge while receiving everybody else's knowledge for a period. After this first period, the firm would lose its membership in the consortium. Its profits in the repeated game can be represented as follows:

$$\pi_i^{travel-cheat}(x) = \frac{\left[a-\alpha-(\beta+\gamma)(N-2)+\beta N(N-1)\right]}{b(N+1)^2} - \frac{d}{2} + \delta\frac{\pi^{nottravel-cheat}}{1-\delta}$$

(3.5)

Our focus in this study is to figure out how distance plays out as a decisive equilibrium factor, that is, we would like to find the threshold distance below which cooperation is an equilibrium. The larger this distance, we would conclude, the more the firms would be able to cooperate over larger distances from the consortium. Hence, following (3.3) and (3.5), one could find the maximum distance, the distance threshold, at the equilibrium between the member firms and the consortium that would support knowledge exchange, given sufficiently small and large reciprocity.

Proposition [2] For traveling to the consortium, *knowledge sharing is an equilibrium in the repeated game if*

$$d < D_C = \begin{cases} \left[\pi_i^{cooperate} \frac{d-2}{(1-\delta)} - \pi_i^{notravek-cheat} (1-\delta) \right] if\, \gamma \geq \frac{\beta}{(N-1)} \\ \frac{2}{\delta} \left[\pi_i^{cooperate} - \delta(1-\delta)\pi_i^{notravel-cheat} - (1-\delta)\left(\pi_i^{travel-cheat} + \frac{d}{2} - \delta \frac{\pi_i^{notravel-cheat}}{1-\delta} \right) \right] if\, \gamma < \frac{\beta}{(N-1)} \end{cases}$$

This proposition shows that as reciprocity gets larger, the distance between the member firms will grow and the consortium gets for supporting cooperation. We also find that the distance below which cooperation is equilibrium is more sensitive to the reciprocal learning parameter in comparison to the unilateral learning parameter. We also find that knowledge exchange is sustainable across larger distances when it is more effective in reducing costs regardless of the exchange form and that the distance below which cooperation is sustainable is more sensitive to reciprocal learning.

[2] The proposition is obtained by subtracting (3.4) and (3.5) from (3.3) and pulling out the distance parameter *d* for each.

3.4 CONCLUSION

Our main finding in this study supports the claim that increased reciprocity in learning supports knowledge exchange within a consortium over greater distances, given that travel costs matter in such exchange and cheating is possible. The findings are useful in motivating sharing plans that would involve and monitor increased reciprocity of learning within the consortium. Such a result certainly sheds light on the sustainability of research alliances, given the significance of knowledge transfer among member firm employees.

Chapters 4 and 5 delve into the black box of skilled labor agglomeration in terms of the issues that affect the retention of the highly skilled labor in regions focusing particularly on native-born versus naturalized American citizens. Further, in Chapter 5 we try to explain the spatial clustering of certain ethnicities in U.S regions focusing on native-born citizens versus H1-B visa holders. These two chapters nicely complement the first three chapters by focusing on the mechanics of agglomerations, detailing the factors that explain labor mobility, and taking into account the significance of highly skilled foreign labor in the United States.

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