Modelling Collaboration Formation with a Game Theory Approach

Jbid Arsenyan, Gülçin Büyüközkan, Orhan Feyzioğlu

Abstract— **Collaboration, by definition, is a process where two or more parties (individuals or organizations) join resources and knowledge to achieve common goals. Globalization and competitiveness in today's market conditions compel firms to collaborate in order to reduce development costs and time-to-market. In order to model and analyze conditions under which collaborations are formed, this paper proposes to employ a game-theoretic approach, given that Game Theory attempts to model and analyze strategic situations, including various types of games suitable for different settings. A mathematical model is proposed for Collaborative Product Development and a Nash Bargaining solution is proposed in a numerical analysis.**

Index Terms— **Bargaining, Collaborative Product Development, Game Theory, Profit sharing.**

I. Introduction

COLLABORATION between firms in order to share R&D investments, product development (PD) costs and reduce time-to-market becomes more and more common with increasing market competition and globalization. Collaboration includes creation and sharing of knowledge about markets and technologies, setting market standards, sharing facilities, etc [1]. The benefits of collaboration efforts can only be defined by analyzing the conditions that collaboration requires. Game Theory is the formal investigation of conflict and collaboration and is applied to situations where two or more parties interact. Therefore, game-theoretic principles are applied to analyze collaboration efforts in PD. This study attempts to mathematically model the profit for the collaborative parties and identify the conditions under which the collaborative equilibrium is achieved.

The implication of collaboration goes beyond sharing of revenues [2]. Collaboration engenders knowledge sharing and innovation as well. In this respect, a mathematical model is required to model the variables such as investment, knowledge, trust, innovation, cost and revenue, as well as the level of sharing and collaboration. The aim of this study is to structure these variables in order to offer a model of collaboration formation. First and foremost, the model needs to put forward a negotiation environment where each party of collaboration benefits from it, i.e., a win-win situation. The win-win situation is required to balance the contribution of each variable from each party by defining the level of sharing. The model needs to be described with a reference point other than revenue, given that collaboration between organizations does not solely aim to increase revenue, but also seeks to learn and innovate by joining knowledge and technology, cultivating trust and assuring coordination. The model needs to present how collaborative parties should interact with each other in order to improve total effectiveness of the process.

In this study, a game-theoretic approach for collaboration formation is presented to tackle the aforementioned issues. The paper is organized as follows: next section introduces Game Theory and collaboration concepts with some background and description. Section III introduces the mathematical model for Collaborative Product Development (CPD). Section IV describes the numerical analysis conducted on the mathematical model. The paper concludes with a few remarks.

Manuscript received March 23, 2011; revised March 23, 2011. Authors wish to thank TUBITAK for the financial support. Gülçin Büyüközkan also acknowledges the financial support of the Galatasaray University Research Fund.

J. Arsenyan is with Bahcesehir University Industrial Engineering Department, Istanbul, 34100, Turkey (e-mail: jbid.arsenyan@bahcesehir.edu.tr).

G. Buyukozkan is with Galatasaray University Industrial Engineering Department, Istanbul, 34357, Turkey. (phone: +90 212 227 4480; e-mail: gulcin.buyukozkan@gmail.com).

O. Feyzioğlu is with Galatasaray University Industrial Engineering Department, Istanbul, 34357, Turkey. (e-mail: ofeyzioglu@gsu.edu.tr).

II. Game Theory

A. Background

Forming groups and collaborations is an essential problem in Game Theory literature [1]. Introduced by von Neumann and Morgenstern [3], Game Theory is an applied mathematics branch employed in many domains such as economical behavior, politics, management and organization, etc.

There exist various applications of Game Theory in collaboration research. Early studies date back to the appearance of strategic ventures in 1990's. Parkhe [4] develops a model incorporating Game Theory and cost economics in order to analyze the formation, management and completion of strategic ventures. Larsson et al. [5] integrates Game Theory, strategic venture, institutional learning and collective action literatures in order to observe the development, performance and longevity of strategic ventures.

There also exists a Game Theory literature on strategic partnerships in supply chain. Studies such as collaboration among supply chain actors [6], modeling of buyer-supplier relation with cooperative/non cooperative games [7],

ISBN: 978-988-18210-6-5
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

modeling of customer-supplier relation with Game Theory approach [8] can form a basis for CPD research.

A vast literature can be found on R&D collaborations. These studies generally cover issues of partnerships within one industry and analyze the cost sharing and pricing mechanisms. On the other hand, CPD literature is limited on the Game Theory studies. Xiao et al. [9] model the relationships between engineering teams using Game Theory principles in order to facilitate the collaborative decision making and they investigate the effect of design competence on design freedom. Phelan et al. [10] models the behavior towards an opportunistic partner using prisoner's dilemma with an exit option. They conclude that the opportunistic partner should be given a second chance if high expectations are involved. Arend [11] also employs prisoner's dilemma to observe two-firm collaboration and state that while literature argues that reputation benefits collaboration, empirical evidence shows that collaboration diminishes as reputation increases.

Cai and Kock [12] employ evolutionary Game Theory in order to determine whether or not to collaborate and the amount of collaboration. They use prisoner's dilemma and Snowdrift Game Theory notions, including social punishment, and they investigate e-collaboration game with discrete strategies. Another important Game Theory research is introduced by Bhaskaran and Krishnan [2], where they define three collaboration models (revenue sharing, investment sharing and innovation sharing) and they define equilibrium points with Nash bargaining game under technology and timing uncertainties.

In CSD literature, Hazzan and Dubinsky [13] investigate Extreme Programming in prisoner's dilemma framework, while Tenenberg [14] studies institutional analysis of software teams.

Amaldoss focus on strategic partnerships in his Game Theory applications. Amaldoss et al. [15] investigate the concept of coopetition (collaboration to compete) and they observe the control of resource attributed to collaboration. Non-cooperative non-zero sum games are used to model and analyze equilibrium in various types of partnerships. Amaldoss and Rapoport [16] analyze the effect of the number of networks competing to develop a product, the number of alternative technology platforms, and market sensitivity to product development expenditures on investments of partnering firms using Game Theory principles. Amaldoss and Staelin [17] employ a Game Theoretical model to investigate investment behaviors in cross-functional and same-function alliances.

Chen and Li [18] model team behavior of multifunctional product design teams toward design alternatives, using Fuzzy Sets Theory. Strategic team paradigms derived from Game Theory principles as well as responsibility and controllability notions are employed to ensure team agreement. Takai [19] analyzes collaboration in engineering design using Game Theory and defines collaboration conditions of two engineers in order to maximize product performance within prisoner's dilemma framework.

Samaddar and Kadiyala [20], focus on collaborations with knowledge creation purposes and they investigate conditions to share resources and maintain collaboration. They analyze models with and without prior knowledge using Stackelberg leader-follower framework. Ding and Huang [21] employ this study and investigate the effect of knowledge spill-over using the same framework.

B. Collaboration Process

Collaboration process differs from partnership formation given that its goal focuses on collaboration dynamics. According to Chapman and Corso [22], stability and effectiveness of a network is strongly dependent on softer issues such as open communication, knowledge sharing, trust and common goals. Accordingly, four dimensions can be identified for collaboration process: trust, coordination, co-learning and co-innovation [23]. Building open, trust-based relationships is the key to successful partnership development, and integrated information systems facilitate the flow of data and information between staff [24]. Understanding the role of trust in collaboration during inter-organizational process implementation can potentially increase the probability of achieving a successful B2B implementation that leads to a productive longer-term relationship [25].

An approach for each person and for most encounters can then be developed by typically working through three steps: exchange of vision; negotiate agreement; and negotiate trust [26]. Therefore, trust is the first dimension to examine. The parties have to seek trusting among many partners, relying on social control mechanism in the system composed of network and innovation and outsourcing in the global networked economy [27]. Firms participating in horizontal alliances appear to be less trusting of their partners compared to firms in vertical alliances, which suggests that the presence of relationship norms such as trust may not be able to overcome the fear of opportunism when a firm collaborates with competitors [28]. Coordination is another key factor in collaboration given that various teams from different organizations on different sites are engaged for the same purpose and their efforts must be coordinated.

Improved learning is partly the result of effective communication and information distribution systems, both within and between organizations [29]. Co-learning consequently emerges as another key issue in collaboration. Identifying relevant knowledge inputs from the various partner organizations needs to be viewed as a constant [24]. A key goal for firms is to shift from an essentially static approach to learning, based on information acquisition, towards a greater emphasis on information interpretation and distribution [29]. In a global networked economy with rapid technology change and an increasing need for sharing information and cooperative R&D, information leakage is a core problem in collaboration [27]. As a result, information sharing emerges as an important aspect of collaboration that needs to be balanced. Knowledge is accumulated both through internal capacities of the agent and through the direct and indirect connections that allow to have access to others' knowledge [30] and this constitutes the co-learning.

Firms can find ways in which to innovate and at the same time place innovation within the context of sustainable development through partnerships [24]. Therefore co-innovation appears to be another key factor in collaboration. The search for agreement on the innovation applies to both internal and external people [26] as knowledge is accumulated both internally and externally [30]. Carayol and Roux [30] state that expected number of innovation is a function of accumulated knowledge. This constitutes a link between co-learning and co-innovation, which cannot be stated separately from trust and coordination in collaboration.

These four key dimensions mentioned above are consequently employed to model the collaboration formation. Next section describes the model as well as its variables and parameters.

III. Mathematical Model

In this section, CPD is modeled as profit functions of two firms that must decide on the level of collaboration, level of investment sharing and level of profit sharing. The model includes the four dimension of the collaboration process, described earlier. It includes the revenues and the costs anticipated from CPD efforts. Only two firms, focal firm (F) and partner firm (P), are considered. It is assumed that the partners undertake an innovation sharing, i.e. undertaking all development efforts collaboratively as described in [2].

Three major assumptions are made to develop the model.

Assumption 1

Collaboration creates added value for the product development process [2].

Assumption 2

Collaboration engenders a collaboration cost, resulting from the coordination efforts and knowledge spillovers. When the development effort is distributed between the firms, integration costs are incurred [2].

Assumption 3

Collaboration reduces development cost. The division of innovation across the two firms could lead to lower development costs in comparison to the case in which this innovation were to be done in a single firm [2].

The presented model is based on three different models from [2], [31], and [32]. These different models are integrated in order to best fit the assumptions aforementioned and include the four dimensions of the collaboration process.

First of all, a collaboration level θ is defined, where $\theta = 0$ means no collaboration and $\theta = 1$ means full collaboration. Firms' involvement in decision process increases as θ increases. Accordingly, revenues and some portion of the cost also increase in function of θ. It is expected that firms' investment will increase as the firms' invest more effort in CPD process. On the other hand, it is also expected that firms' revenue share will be much higher as they are more involved in the development and decision processes.

Then knowledge sharing and new knowledge creation is defined. Cowan et al. [31] highlight firms' abilities to effectively integrate each other's knowledge. Consequently, it becomes important to include knowledge spillover and knowledge absorption into the model. When two firms collaborate, they pool their knowledge and use that as input into new knowledge production [31].

Knowledge stock definition is based on the model presented by [32]. However, knowledge is extended to include different types of knowledge, as presented in [31]. Each firm is assumed to hold N distinct types of knowledge.

Total knowledge for knowledge type $i \in \{1, \dots, N\}$ is the sum of the firm's own investment into knowledge and the learning occurred from the collaboration, defined as follows:

$$z_i = M_i^F + M_i^P + \theta\left[\gamma^F(M_i^F,\beta_i)M_i^{P^{t_{PF}}} + \gamma^P(M_i^P,\beta_i)M_i^{F^{t_{FP}}}\right]$$

Total knowledge for knowledge type i, where i represents the number of knowledge type necessary for the development, is a concave function. Total knowledge is represented by the N-dimensional knowledge vector $\boldsymbol{z}$. M_i^j is the firm j's investment in knowledge type i. γ is a function of M_i^j as well as β_i, where β_i is the knowledge complementarity for the knowledge type i. ***Trust***, one of the four dimensions of the collaboration process, is integrated into the model within the knowledge sharing. t_{jk} represents the trust level of firm j towards firm k. $M_i^{j^{t_{jk}}}$ represents the knowledge sharing of firm j, increasing t. Basically, firm j reveal more of its knowledge as the trust towards firm k increases. Literature shows that trust has a positive effect on information sharing and it is important for collaborative relationships not only for effective partnerships, but also for collaborative venture performance [33]. Therefore, we assume that co-learning diminishes as trust decreases. Also, trust is not reciprocal and each firm has a personal degree of trust towards its partner.

Consequently, $\gamma^F(M_i^F,\beta_i)M_i^{P^{t_{PF}}} + \gamma^P(M_i^P,\beta_i)M_i^{F^{t_{FP}}}$ embodies ***co-learning*** occurred from the collaboration. It increases as θ increases given that the higher the collaboration level, the higher the interaction and consequently, learning.

Profits of both firms from the collaboration are a function of the collaboration level and are defined as follows:

$$\Pi^F = \phi * (a + \boldsymbol{bz}\tilde{v}) - \left(\sum_i M_i^F + (1-k)s(\theta) + \sum_i c_i^F(z_i)\right)$$

$$\Pi^P = (1-\phi) * (a + \boldsymbol{bz}\tilde{v}) - \left(\sum_i M_i^P + ks(\theta) + \sum_i c_i^P(z_i)\right)$$

Revenue from the CPD efforts is derived from [2]. Basically it states that revenue is the sum of initial value of the product and the added value created during the collaboration process. When $a = 0$, it is a new-revenue project and when $a > 0$, it represents it is an improvement project [2].

$\boldsymbol{z}$ is the N-dimensional pooled knowledge vector of the collaboration consisting of z_i's.

$\boldsymbol{b}$ is a N-dimensional value creation vector and $\boldsymbol{b} * \boldsymbol{z}$ represents the value added by innovative efforts. $\tilde{v}$ represents market uncertainty, it is an uniformly distributed random variable. Briefly, it can be said that the ***co-innovation*** dimension of the collaboration process is represented as $\boldsymbol{b} * \boldsymbol{z} * \tilde{v}$. The final product value is affected by the innovation.

Each firm gets a fraction $\emptyset_i$ of the total revenue. However, as the current model includes only two firms, we consider that focal firm F gets a fraction $\emptyset$ of the profit whereas partner firm P gets a fraction $(1-\emptyset)$. The model assumes that partners share all development and innovation costs. $\emptyset$ is determined as a function of the bargaining between firms.

The model consists of three types of costs: R&D

ISBN: 978-988-18210-6-5
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

investment, integration cost, and production cost.

Investment cost is the sum of firm's total investment in all types of knowledge.

Collaboration cost is the same for both firms and it represents the ***coordination*** dimension of the collaboration process. The economic costs of complete secrecy or full sharing are higher than the costs of intermediate cases [32]. Therefore $s(\theta)$ is a convex function representing collaboration cost. Collaboration cost is divided between firms. Firms endure k and $1-\mathrm{k}$ fractions of the integration efforts.

Production cost is presented by a convex function $c^j(z_i^j)$. $\frac{\partial c^j(z_i^j)}{\partial z_i^j} < 0$ and $\frac{\partial^2 c^j(z_i^j)}{\partial^2 z_i^j} < 0$. $c^j(0) = C_0 < \infty$ and $c^j(\infty) = C_N$. Production cost is different for each firm.

It is clear that the profit functions are concave. It is assumed that production costs will decrease as knowledge increases.

IV. Numerical Analysis

For the analysis, the instance with only one type of knowledge is considered, therefore z is one-dimensional. Collaboration cost is assumed to be $s(\theta) = I * \theta^2$. Absorption capacity is adapted from [32] and it is $\gamma(M^j, \beta) = M^j * \beta + (1-\beta)$. Total knowledge, which is the sum of prior knowledge and knowledge creation occurred from collaboration, can be expressed as follows:

$$z = M^F + M^P + \theta\left[(M^F\beta + 1 - \beta)M^{P^{t_{PF}}} + (M^P\beta + 1 - \beta)M^{F^{t_{FP}}}\right]$$

For simplification purposes, we set co-learning as $Z_1 = \left[(M^F\beta + 1 - \beta)M^{P^{t_{PF}}} + (M^P\beta + 1 - \beta)M^{F^{t_{FP}}}\right]$.

Production cost is expressed as $(c^j - d^j * Z_1)$, the cost decreases as co-learning increases.

Expected value of the random variable $\tilde{v}$ is $\frac{v+1}{2}$ it follows a continuous uniform distribution.

The profit functions of focal and partner firms consequently become:

$$\Pi^{\mathrm{F}} = \phi(a + b\left(\frac{v+1}{2}\right)z) - (M^F + (1-k)I\theta^2 + (c^F - d^F Z_1\theta))$$

$$\Pi^{\mathrm{P}} = (1-\phi)(a + b\left(\frac{v+1}{2}\right)z) - (M^P + kI\theta^2 + (c^P - d^P Z_1\theta))$$

For the numerical analysis proposed in this paper, we consider the instance where production cost of both firms are equal, i.e. $d^P = d^F = d$ and $c^P = c^F = c$. Moreover, we consider a new-revenue project, therefore $\mathrm{a} = 0$. Both firms' knowledge investments are equal and $M^P = M^F = M$. Trust degree of both firms is at its maxima, $t = 1$. Knowledge complementarity is assumed to be $\beta = 0{,}5$, which results in $Z_1 = M(M+1)$.

Both b and $\left(\frac{v+1}{2}\right)$ are assumed to be equal and have unit value, yielding to $Z_3 = b\frac{(v+1)}{2} = 1$.

It is assumed that the focal firm makes the decision on the collaboration level. Given that the focal firm initiate the collaborative activities, it is normal to suppose that the collaboration level is determined according to the requirements of the focal firm. Therefore, optimal θ is calculated through the profit function of the focal firm.

$$\theta^* = \frac{M(M+1)(d+\emptyset)}{2I(1-k)}$$

θ^* is inserted into the profit function of the partner firm, in order to compute optimal fraction of integration cost in respond to the given collaboration level. The proportion of collaboration cost which is endured by the partner firm is then expressed as:

$$k^* = \frac{d + (2 - 3\emptyset)}{3d + (2 - \emptyset)}$$

It is obvious that k^* is feasible if and only if $\emptyset < \frac{2}{3}$.

The optimal solutions for collaboration level and integration cost fraction are inserted into the profit functions of both firms. The equilibrium $\emptyset$ would be the solution to the Nash bargaining problem:

$$\max_{0 \le \phi \le 1} \pi_{\mathrm{B}} = \pi_{\mathrm{F}}\pi_{\mathrm{P}}$$

We set $M = \frac{I}{10} = 10$ and $c = 100d = 1$. The maxima of the bargaining problem is unique and $\emptyset^* = 0{,}5$.

With these parameters, we obtain $k^* = 0{,}334$ and $\theta^* = 0{,}4208$.

These solutions conclude that when all cost and revenue parameters are equal, the profit must be shared equally. However, given the ration of investment in knowledge over the investment in coordination, it is more economical not to collaborate entirely. Partner firm, accordingly, only endures a third of the integration cost.

V. Conclusion

The presented model integrated the four dimensions of collaboration process in CPD and presented a mathematical profit model that captures both the revenue generated by the innovation and the cost occurring from the collaboration. The mathematical model provides an understanding on the working of the collaboration dimensions, expressed as parameters. It provides visualization on the effect of collaboration level on revenues and costs occurred from collaboration, as opposed to the situation without collaboration.

Further study will provide a more in-depth analysis of the current model. The instances where trust degrees, investments in knowledge, production costs, etc. are different for each company will be investigated in order to obverse the proposed model's behavior and the compatibility with the real-life collaborative activities.

References

[1] S. Goyal and S. Joshi, "Networks of collaboration in oligopoly," *Games and Economic Behavior*, vol. 43, pp. 57-85, 2003.

[2] S.R. Bhaskaran and V. Krishnan, "Effort, Revenue, and Cost Sharing Mechanisms for Collaborative New Product Development," *Management Science*, vol. 55, no. 7, pp. 1152-1169, 2009.

[3] J. von Neumann and O. Morgenstern, *Theory of Games and Economic Behavior*. New Jersey: Princeton University Press, 1944.

[4] A. Parkhe, "Strategic alliance structuring: A game theoretic and transaction cost examination of interfirm cooperation," *Academy of*

ISBN: 978-988-18210-6-5
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Management Journal, vol. 36, no. 4, pp. 794-829, 1993.

[5] R. Larsson, L. Bengtsson, K. Henriksson, and J. Sparks, "The Interorganizational Learning Dilemma: Collective Knowledge Development in Strategic Alliances," *Organization Science*, vol. 9, no. 3, pp. 285-305 , 1998.

[6] M. Nagajaran and G. Sosic, "Game-Theoretic Analysis of Cooperation Among Supply Chain Agents: Review and Extensions," *European Journal of Operational Research*, vol. 187, no. 3, pp. 719-745, 2008.

[7] M. Esmaeili, M.-B. Aryanezhad, and P. Zeephongsekul, "A game theory approach in seller-buyer supply chain," *European Journal of Operational Research*, vol. 195, p. 442–448, 2009.

[8] T. Laaksonen, T. Jarimo, and H.I. Kulmala, "Cooperative strategies in customer–supplier relationships: The role of interfirm trust," *International Journal of Production Economics*, vol. 120, no. 1, pp. 79-87, 2009.

[9] A. Xiao, S. Zeng, J. Allen, D. Rosen, and F. Mistree, "Collaborative multidisciplinary decision making using game theory and design capability indices," *Research in Engineering Design*, vol. 16, no. 1, pp. 57-72, 2005.

[10] S.E. Phelan, R.J. Arend, and D.A. Seale, "Using an Iterated Prisoner's Dilemma with Exit Option to Study Alliance Behavior: Results of a Tournament and Simulation," *Computational & Mathematical Organization Theory*, vol. 11, no. 4, pp. 339 - 356 , 2005.

[11] R.J. Arend, "Reputation for cooperation: contingent benefits in alliance activity," *Strategic Management Journal*, vol. 30, p. 371–385, 2009.

[12] G. Cai and N. Kock, "An evolutionary game theoretic perspective on e-collaboration: The collaboration effort and media relativeness," *European Journal of Operational Research*, vol. 194, no. 3, pp. 821-833, 2009.

[13] O. Hazzan and Y. Dubinsky, "Social Perspective of Software Development Methods: The Case of the Prisoner Dilemma and Extreme Programming," in *Extreme Programming and Agile Processes in Software Engineering*. Heidelberg: Springer Berlin, 2005.

[14] J. Tenenberg, "An institutional analysis of software teams," *International Journal of Human-Computer Studies*, vol. 66, no. 7, pp. 484-494 , 2008.

[15] W. Amaldoss, R.J. Meyer, J.S. Raju, and A. Rapoport, "Collaborating to Compete," *Marketing Science*, vol. 19, no. 2, pp. 105-126, 2000.

[16] W. Amaldoss and A. Rapoport, "Collaborative Product and Market Development: Theoretical Implications and Experimental Evidence," *Marketing Science*, vol. 24, no. 3, pp. 396-414, 2005.

[17] W. Amaldoss and R. Staelin, "Cross-Function and Same-Function Alliances: How Does Alliance Structure Affect the Behavior of Partnering Firms?," *Management Science*, vol. 56, no. 2, p. 302–317, 2010.

[18] L. Chen and S. Li, "Modeling Concurrent Product Design: A Multifunctional Team Approach," *Concurrent Engineering*, vol. 8, no. 3, pp. 183-198, 2000.

[19] S. Takai, "A Game-Theoretic Model Of Collaboration In Engineering Design ," *Journal of Mechanical Design* , vol. 132, no. 5, 2010.

[20] S. Samaddar and S.S. Kadiyala, "An analysis of interorganizational resource sharing decisions in collaborative knowledge creation," *European Journal of Operational Research*, vol. 170, no. 1, pp. 192-210, 2006.

[21] X.-H. Ding and R.-H. Huang, "Effects of knowledge spillover on inter-organizational resource sharing decision in collaborative knowledge creation," *European Journal of Operational Research*, vol. 201, no. 3, pp. 949-959, 2010.

[22] R. L. Chapman and M. Corso, "From continuous improvement to collaborative innovation: the next challenge in supply chain management ," *Production Planning & Control* , vol. 16, no. 4, pp. 339-344, 2005.

[23] J. Arsenyan and G. Buyukozkan, "Modelling Collaborative Software Development Using Axiomatic Design Principles," *International Journal of Computer Science*, vol. 36, no. 3, 2009.

[24] P.R.J. Trim and Y.-I. Lee, "A strategic approach to sustainable partnership development," *European Business Review*, vol. 20, no. 3, pp. 222-239, 2008.

[25] Y. L. Lederer-Antonucci, P. S. Greenberg, M. zur Muehlen, and G. Ralph, "Establishing trust in a business-to-business collaboration: Results from an international simulation," in *Proceedings of IRMA 2003 Conference*, Philadelphia, 2003, pp. 922-924.

[26] Ian Roffe, "Strategic planning for the development of a training innovation," *Journal of European Industrial Training*, vol. 22, no. 2, p. 57–65, 1998.

[27] Y. Yong, L. NengSheng, and B. Hong, "Technology innovation and risks in outsourcing," in *The 2008 International Conference on Risk Management & Engineering Management*, 2008, pp. 416-421.

[28] A. Rindfleisch, "Organizational Trust and Interfirm Cooperation: An Examination of Horizontal versus Vertical Alliances ," *Marketing Letters* , vol. 11, no. 1, pp. 81-95, 2000.

[29] J. Barlow and A. Jashapara, "Organisational learning and inter-firm “partnering” in the UK construction industry," *The Learning Organization*, vol. 5, no. 2, p. 86–98, 1998.

[30] N. Carayol and P. Roux, "'Collective Innovation’ in a Model of Network Formation with Preferential Meeting," in *Nonlinear Dynamics and Heterogeneous Interacting Agents*. Berlin: Springer Berlin Heidelberg, 2005, pp. 139-153.

[31] R. Cowan, N. Jonard, and J.-B. Zimmermann, "Bilateral Collaboration and the Emergence of," *Management Science*, vol. 53, no. 7, pp. 1051-1067, 2007.

[32] M. Sakakibara, "Knowledge Sharing in Cooperative Research and Development ," *Managerial And Decision Economics* , vol. 24, p. 117–132 , 2003.

[33] P.K. Couchman and L. Fulop, "Examining partner experience in cross-sector collaborative projects focused on the commercialization of R&D," *Innovation: management, policy & practice*, vol. 11, no. 1, pp. 85-103, 2009.

[34] R. Krishnan, X. Martin, and N.G. Noorderhaveni, "When Does Trust Matter To Alliance Performance," *Academy of Management Journal*, vol. 49, no. 5, p. 894–917, 2006.

[35] M. Antaki, A. Schiffauerova, and V. Thomson, "The Performance of Technical Information Transfer in New Product Development," *Concurrent Engineering*, vol. 18, pp. 291-301, 2010.