Framework of Evaluating Business Partner Recommendation Beyond Industry Types Toward Virtual Corporation

Taisei Mukai(✉)

Department of Inteligence System Science,
Tokyo Institute of Technology, Tokyo, Japan
mukai.t.ad@m.titech.ac.jp

Abstract. We propose a framework to evaluate a recommendation of unknown partners in an inter-business market by an artificial intelligence (AI) and a simulation. The reason is that unknown partner recommendation by AI such as a data mining or machine learning is difficult to evaluate because it is not possible to know correct partners in the real world. The framework is a flow of (1) proposing a method of recommending unknown business partners, (2) installing the recommendation method as AI into a firm agent, and (3) evaluating a recommended business partner by comparing performance between a recommendation method (machine learning, etc.) and an agent-based modeling simulation (ABMs). Since this framework can handle experiments assuming future situations, managers in a firm are possible to consider and judge recommendation methods and recommended partners according to virtual market conditions.

Keywords: Inter-firm market · Partner recommendation · Agent simulation · Machine learning · Virtual corporation

1 Introduction

The objective of this research is to examine the framework for evaluating and judging the partner recommendation for inter-firm trade beyond an industry type toward the virtual corporation by comparing performance between a recommendation method and an agent modeling simulation method [11].

The background of this objective is here. The industry 4.0 [2] has become a hot topic. This is the concept that firms can adapt flexibly to market changes by autonomously connecting factories, machines or workpieces. These connections will be eventually links between firms. The autonomous connection between firms was a concept that became famous as a virtual corporation [5] in the 1990's.

The virtual corporation is a type of firm in which a firm connects by using a network to create a virtual state like one firm in order to achieve its own

F. Koch et al. (Eds.): GEAR 2018, CCIS 999, pp. 49–56, 2019.
https://doi.org/10.1007/978-981-13-6936-0_6

purpose. Even if a market environment changes, firms can adapt to the change by updating their purpose and their form of the virtual corporation [5]. A part of the virtual corporation is realized by consolidation of outsourcing such as a fabless company which do not have actual factories [3], the original equipment manufacturing (OEM) and the original design manufacturing (ODM) [21].

The reasons for such excitement of cooperation among firms are a management of resources via the Internet and the flexibility of business protocols such as the Web-EDI (Electronic Data Interchange) [19]. Furthermore, a recommendation of business partners by AI is also improved remarkably. Then this paper considers how the proposed framework with the AI judges recommended firms and supports the virtual corporation as under such recent technical conditions. This framework is used by the firm's managers to look for clients and providers and consider a trade in the various trade conditions. The case is as follows: (1) Managers look for a better business partner than the current business partner; (2) Managers restore business partners as soon as possible such as after an event of a disaster or look for providers that have high productivity after getting a big client; (3) Managers evaluate the recommended partner by changing a time step.

2 Related Study

We describe researches on business partner recommendation and a framework that can evaluate recommended partners. There are two cases of research on business partner recommendation as follows: (1) a method using information on a firm alone [8,9]; (2) a method using information on multiple firms [13]. The former is a method that learns a firm's performance such as firm credit or expert's estimation, with the information of a firm as features and applies it to the recommendation. The recommendation can be made by evaluating partner candidates prepared in advance. The latter method learns a label such as trade on or off of a trading pair (Client and Provider) by machine learning with binary discrimination using the firm information of the pair as features and recommends business partners by applying it. The paper focuses on the latter method.

However, most of the previous researches on the business partner recommendation are focused on acquiring firm information effective for selecting correct partners rather than recommending business partners. This is because machine learning and data analysis cannot easily judge whether the recommended unknown business partners are correct or not. These methods only learn past actual trades, then it is impossible to know positive labels of unknown trade. The above existing research also did not evaluate unknown partner recommendations.

Therefore, this research considers not only evaluating candidate firms directly using data, but also evaluating the performance of a business partner recommendation using the simulation framework of inter-firm trade in multi-perspective. The agent-based modeling simulation can express changes in the trading environment (requirement and demand) and can experiment with recommended partners by changing the conditions.

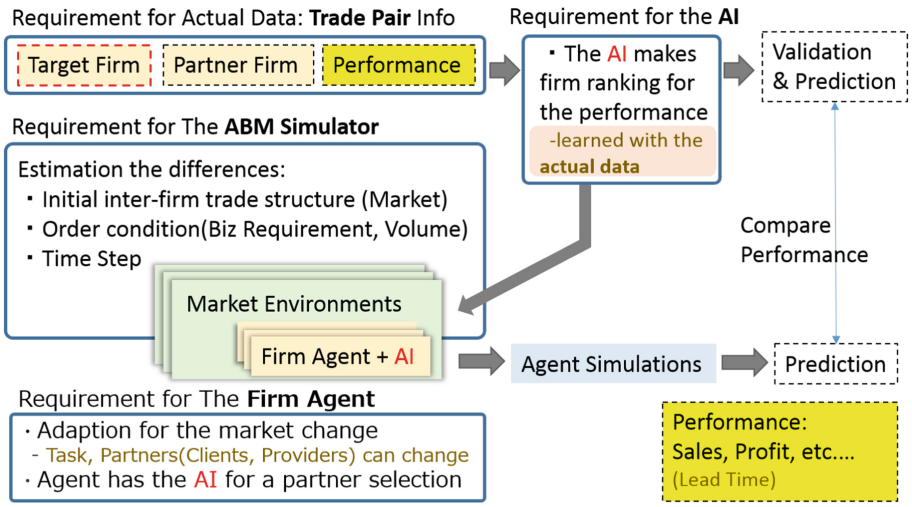

Fig. 1. The proposed framework

3 Proposed Framework

The proposed framework is for evaluating and judging whether the recommended new partners by the AI is good for improving the performance of a target firm. That is, the framework requirement is a comparison of the evaluation of unknown business partners by the AI and simulations in multi-perspective.

Briefly, first, prepare accounting data of the target firm and its business partner firms. Secondly, The AI learns performance indicators such as adjusted profit or sales of the target firm from the accounting data of this trade pair and evaluate it using prediction. Lastly, predict performance indicator by the ABMs in a market environment that firm agents equipped with the AI consist. It is a framework to judge business partners by trying various simulation conditions and comparing these multifaceted results with the results of machine learning (Fig. 1). Below we show the part of the requirements and examples of the proposed framework and how multiple evaluations are possible.

3.1 Requirements for Actual Data

The accounting data of the trading pair should have elements as features in Table 1 at least. Therefore, the framework requires three years' worth of accounting data of the target firm and its business partner firms to catch the sequential change of a state of the trade pairs. The procurement item types are a unique point in the elements.

Table 1. Firm features of a trade pair (Explanatory variable).

Attribute	Feature vectors
Categorical data	Own business item type, procurement item types
Firm information	Sales, profit, capital, worker number, ...
Composite variable	Growth rate, profitability, efficiency, stability, ...

3.2 Requirements for the Partner Recommendation Method (AI)

The recommendation method can be any method as long as it can calculate a ranking for a firm's performance. In this paper, we propose a recommendation algorithm with devising feature vectors (Table 1) and with a machine learning using these feature vectors (Fig. 1).

Recommendation Method Using a Firm Vector Model. First, express the features (Table 1) of a firm which deals with a target business item into feature vectors, and search and list firms of business partners based on the similarity (such as a cosin similarity, etc.) of the feature vectors of previous partners or desired business partners. As an unique idea, vectorize with procurement items of a firm and firm accounting figures (Table 1). As a result, it is possible to recommend firms that have a similar business output beyond its industry type and possibly the same business on its business scale. Firms are easy to trade with firms close to their size [1].

Recommendation Method Using a Machine Learning. For recommendation with a machine learning, it is recommended that both firm information of the new trade pair without trading in the past on real data for the two years after latest are used as feature vectors. The regression as the AI learns the ratio of sales or profit as a target variable (ex. (profit3 - profit2)/profit2 ...in Fig. 2), and after that, this regression predictor makes a ranking for unknown recommending partners in order of the performance (Fig. 2). The previous research [13] used trading pairs, but it was not adaptive to environmental changes because it learned past continued trade, and not leaned time-series trade for target variable and feature variables (vectors).

For example of a machine learning algorithm, a supervised machine learning is preferred. For example, a regression analysis: Multiple regression [4]; Support vector regression (SVR) [23]; or Random forest regression [10]; a multi-class classification: Multi-Class SVM [12], etc., or a artificial neural network can be learned by a regression or a multi-class classification [18,20] or its extended algorithm.

3.3 Requirements for the Firm Agent Model

Requirements for the agent model of an inter-firm is below: (1) Each firm agent adapts for the market change. The concept of a market change has elements of

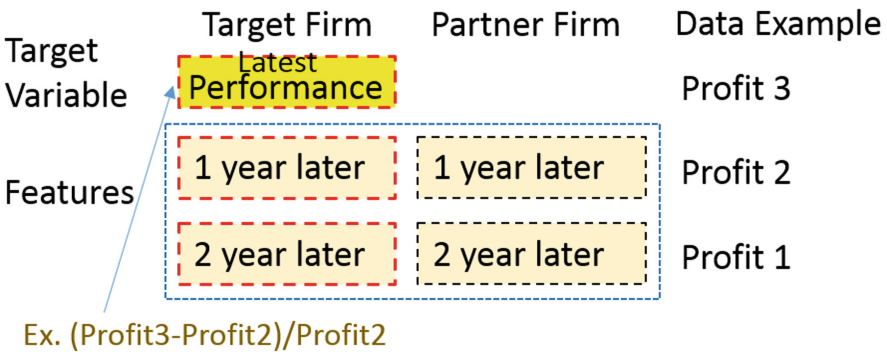

Fig. 2. Actual data of trade pair

business requirement change and business volume change. To meet the market change, the firm agent can change his business task item and his partners (clients and providers) to improve his performance indicators such as a profit or sales. The factors of the model are described in the previous researches [14,15]. This model Mukai proposed is made by expanding the division model that can search for business tasks based on the framework of enterprise behavior of previous research [17]. That's why we use this model.; (2) Each firm agent can equip the AI for the partner selection. See in Fig. 1. ABMs is easy to equip the AI.

Managers can use business partner recommendations for each business category in actual trade data. That is the business category level is a minimum firm agent size. Therefore, The abstraction level of the agent is the middle range [6].

3.4 Requirements for the Simulator

Requirements for the simulator is to estimate the difference below: (1) Difference of initial inter-firm trade structure; (2) Difference of order conditions (Business requirement and volume); and (3) Difference of time step; in this simulation. By comparing these simulation results with the results of machine learning, we judge whether the recommended firm is better or not (Fig. 1).

The simulator [14,15] satisfies these requirements and is characterized by an exploratory search of business items and partners to meets an environmental change in particular (Fig. 3).

Usage of the Framework for Evaluating a Partner Recommendation. We describe a usage of the framework example: (1) Manager can compare simulation cases with and without dealing with recommended firms, in addition to evaluation of a machine learning; (2) Manager can compare simulation cases with and without dealing with business requirement change and volume change as the market change. This operation can express differences in business trade in growth areas and obscure areas. We can consider the differences of business

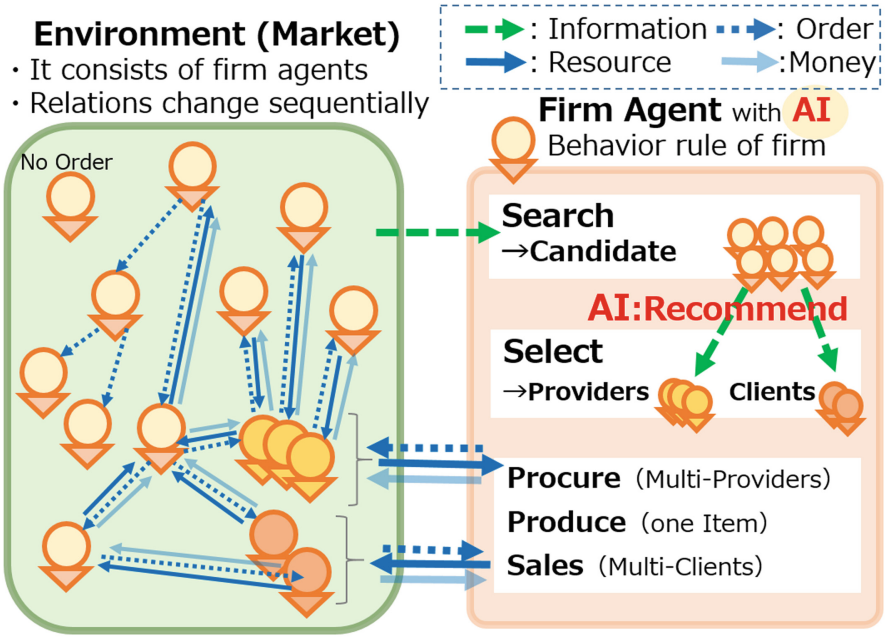

Fig. 3. Agent simulation model for inter-firm trade

partners in the future growth area or not; and (3) Even if the result of machine learning that learned most recent data is bad, the simulation case is a good in the long term or vice versa, or both are good or bad. You can evaluate the recommended partners from these differences.

4 Discussion and Future Work

We proposed the framework that can evaluate an unknown partner recommendation as an environmental adaptation. Even trade data that do not have a past trade can be evaluated according to virtual situations, so that decision can be supported diversely or autonomously in the future.

The objective of this framework is decision support for the manager in a firm, but we also consider to support an automatic trade between firms. In recent years, researches based on smart contracts with a blockchain such as the decentralized autonomous organization (DAO), the decentralized autonomous corporation (DAC) aiming to establish automatic trade are popular [16,22]. Also, considering this autonomous trade as the virtual corporation, If the customer inputs what he wants in a system which deals with the virtual corporation, the trade path will be autonomously searched for, and the trade or service is established, executed or delivered as soon as conditions are matched. For example, the build to order (BTO) [7] realizes this partly so the system of the virtual corporation is easy to imagine.

In other words, the virtual corporation is autonomously constructed and accomplished by the customer just wishing for a service or what they want. The customer does not have to worry about how it was achieved. The proposed framework provides evidences to support this autonomous trade. Alternatively, it may be a role to stop a crazy autonomous trade.

Until now, ordinary customers were difficult to produce and buy what they wanted, unless they use joint purchasing. However, customers will be able to negotiate what they really want on the market through the virtual corporation system that the proposed framework supported.

References

1. Baum, J.A., Rowley, T.J., Shipilov, A.V., Chuang, Y.T.: Dancing with strangers: aspiration performance and the search for underwriting syndicate partners. Adm. Sci. Q. **50**(4), 536–575 (2005)
2. Brettel, M., Friederichsen, N., Keller, M., Rosenberg, M.: How virtualization, decentralization and network building change the manufacturing landscape: an industry 4.0 perspective. Int. J. Mech. Ind. Sci. Eng. **8**(1), 37–44 (2014)
3. Brown, C., Linden, G., Macher, J.T.: Offshoring in the semiconductor industry: a historical perspective. In: Brookings Trade Forum, pp. 279–333. JSTOR (2005)
4. Cohen, J.: Multiple regression as a general data-analytic system. Psychol. Bull. **70**(6p1), 426 (1968)
5. Davidow, W.H., Malone, M.S.: The virtual corporation: structuring and revitalising the corporation for the 21st century. New York (1992)
6. Gilbert, N.: Agent-Based Models, No. 153, Sage, London (2008)
7. Gunasekaran, A., Ngai, E.W.: Build-to-order supply chain management: a literature review and framework for development. J. Oper. Manag. **23**(5), 423–451 (2005)
8. Guo, X., Yuan, Z., Tian, B.: Supplier selection based on hierarchical potential support vector machine. Expert Syst. Appl. **36**(3), 6978–6985 (2009)
9. Guosheng, H., Guohong, Z.: Comparison on neural networks and support vector machines in suppliers' selection. J. Syst. Eng. Electron. **19**(2), 316–320 (2008)
10. Liaw, A., Wiener, M., et al.: Classification and regression by randomforest. R News **2**(3), 18–22 (2002)
11. Macal, C.M., North, M.J.: Tutorial on agent-based modeling and simulation. In: Simulation Conference, 2005 Proceedings of the Winter, 14 pp. IEEE (2005)
12. Mayoraz, E., Alpaydin, E.: Support vector machines for multi-class classification. In: Mira, J., Sánchez-Andrés, J.V. (eds.) IWANN 1999. LNCS, vol. 1607, pp. 833–842. Springer, Heidelberg (1999). https://doi.org/10.1007/BFb0100551
13. Mori, J., Kajikawa, Y., Kashima, H., Sakata, I.: Machine learning approach for finding business partners and building reciprocal relationships. Expert Syst. Appl. **39**(12), 10402–10407 (2012)
14. Mukai, T., Terano, T.: Modeling decentralized inter-organizational business structures through agent-based simulation. In: World Automation Congress (WAC), pp. 1–8. IEEE (2016)
15. Mukai, T., Terano, T.: Effects of trade environment in decentralized inter-organizational business structures through agent simulation. J. Adv. Comput. Intell. Intell. Inf. (JACIII) **22**(6), 933–942 (2018)

16. Norta, A.: Creation of smart-contracting collaborations for decentralized autonomous organizations. In: Matulevičius, R., Dumas, M. (eds.) BIR 2015. LNBIP, vol. 229, pp. 3–17. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-21915-8_1
17. Okada, I., Ohta, T.: Psychological personality and organizational performance with MAS simulation. In: Agent-Based Approaches in Economic and Social Complex Systems, vol. 2, p. 35 (2002)
18. Ou, G., Murphey, Y.L.: Multi-class pattern classification using neural networks. Pattern Recogn. **40**(1), 4–18 (2007)
19. Ronchi, S.: The Internet and the Customer-Supplier Relationship. Routledge, New York (2018)
20. Specht, D.F.: A general regression neural network. IEEE Trans. Neural Networks **2**(6), 568–576 (1991)
21. Su, Y.f., Yang, C.: A structural equation model for analyzing the impact of ERP on SCM. Expert Syst. Appl. **37**(1), 456–469 (2010)
22. Swan, M.: Blockchain thinking: the brain as a DAC (decentralized autonomous organization). In: Texas Bitcoin Conference, Chicago, pp. 27–29 (2015)
23. Vapnik, V.: The Nature of Statistical Learning Theory. Jordan, M., Lauritzen, S.L., Lawless, J.L., Nair, V. (eds.) (1995)