論文題目　　A Game-theoretic Analysis of Subsidy Effects on New Technology Development: A Case of Internet of Vehicles
（新技術開発における補助金の影響についてのゲーム理論的分析：Internet of Vehicles を事例として）

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In this research, we aim to clarify the subsidy affection on new technology development, especially for the technologies with multiple-attributes like Internet of vehicle (IoV). Since customers choose their preferable technology based on some attractive attributes and its corresponding price instead of all attributes, taking each attribute and its corresponding subsidy into account separately can make a clear understanding that how subsidy of each attribute affect the technology development as a whole. Therefore, this dissertation focus on answering one question that how subsidy of each attribute affects the price of technology and its attribute technology level according to the structure of customers' willingness to pay (WTP). To well illustrate this issue, we also conducted a case study in auto field in China. The net contribution of this dissertation is analyzing the subsidy affection on technology development by taking technology attributes and customers' WTP into account. This dissertation is structured into six chapters.

First chapter, it is an introduction part and has four sections including background, objective, methodologies and structure. In this chapter, we emphasize the importance of the technology development and the trend of the vehicle industry. Given the outline of the Chinese government subsidy policy on technology development especially on hi-tech product and the policies from central government to local government, we can fully figure out that Chinese manufacturing has changing its strategy from quantity to quality. In order to fulfill this strategy, subsidy is the most frequent tool to support the industry directly.

In the second chapter, we went though over 400 papers and books among five fields

including IoV technology, conjoint analysis, WTP, subsidy on hi-tech and game theory on subsidy issues to make a clear position of this dissertation. We find out that this dissertation first use WTP to measure a future product instead of a real entity. Also, this dissertation considers the affection of subsidy on technology level of product attribute firstly. Previously, scholars majorly took the product as a whole and considered the characters of the product together. Finally, most researchers use game theory to solve the existing problem like market competition. However, in this dissertation, game theory is a tool of guidance of technology development.

In the chapter three, we aimed to explore the customer preference of IoV attributes and their corresponding technologies since technology of IoV consists of seven attributes in common. In doing so, we conducted a survey backed by conjoint analysis to reveal the popularity of each attribute. From the survey, we figured out top three most popular attributes of IoV among seven attributes. They are safety, well-being and moving management. Based on the first survey result, the top three attributes, we conducted the second survey. We used bid and ask method to reveal the WTP distribution of top three attributes among these customers and we found that the WTP distribution of top three attributes followed uniform distribution nearly. In terms of related technologies of the top three attributes, we conducted two expert interviews by semi-structured form. By these interviews, we aimed to point out the core technology of IoV during manufacturing instead of academic stage and qualitatively rank these technologies in terms of some specific characters like development risk, government support. As the expert point of views, we found that vehicle component, software and communication technologies were most related to the attributes of safety, well-being and moving management respectively.

Turning into the game model part, for the model part, to reveal the early stage of technology development, a simple model of subsidy affection on new technology development with one attribute and fixed technology level has been put forward in chapter four. This is a sequential game among manufacturers, customers and government and consists of two manufacturers, one government and a set of customers whose WTP of IoV follow uniform distribution. By solving the game, analytical solution has been calculated to derive the Nash equilibrium. In this model, we found government's subsidy had a positive affect on product promotion within some range. When beyond some limitations, the positive affection of extra subsidy would decrease, especially for the situation that the market is fully occupied. In order to reveal the mechanism of subsidy affection on technology intuitively, three scenarios have been put forward according to different WTP

distribution and cost structure of IoV technology. We found that government subsidy would benefit advanced manufacturer a lot if advanced manufacturer has a higher WTP distribution or better cost-structure.

The fifth chapter of dissertation is the general model of subsidy affection on new technology development with multiple-attributes and changeable technology level. In this chapter, the decision variables of manufacturers are not only the price, but also the technology level of each attribute. The decision is happened simultaneously between the two manufacturers. Differential the decision variables by subsidy and assumption of second order conditions, we found under certain conditions, increasing subsidy can promote the technology level and price. Within the numerical analysis, several scenarios according to the cost structure, WTP, social benefit coefficient were put forward to reveal the characters of this model including a special scenario that two manufacturers are totally identical. We revealed that if the cost of technology were much lower than the maximum WTP of technology among customers, government would hardly give any subsidy to any attribute at Nash equilibrium. Finally, a case based on chapter 3 was used to verify these characters. In the case study of general game, according to the reality data in China, the result shows, under the current situation, government would not give any subsidy to the IoV industry. And we continued to discuss about the possibility of subsidy initiation, the result shows that government would begin to give subsidy only two conditions are satisfied. One is that the attribute should bring enough social benefit per unit, since government subsidy would decrease the government utilities. Increasing the social benefit of product can offset the subsidy cost. The other is that the cost of attribute should be bigger enough which might be over the maximum WTP of customer, which means government can only give subsidy to the attribute which is not profitable.

The final chapter, we made a conclusion of this dissertation. Since there are many limitations of this research including some subjective part like expert interview, we also made some expectations on this future research in this chapter.