Application of Game Theory to Business Decision-making

Yuecheng Xu[1, *]
[1]Faculty of Science, The University of Nottingham-Ningbo (315100), Ningbo, China

Abstract. How to make correct business decisions has become a hot issue that entrepreneurs are concerned about. Some researchers have found that game theory greatly impacts business decisions. However, there is still a lack of a unified explanation of the formation mechanism behind using game theory to make correct business decisions. Therefore, this article explores the use of game theory to make correct business decisions by collecting data on business competition, organizing the data into a benefit matrix, and comparing to conclude, through which the benefits of business cooperation and business competition can be demonstrated. Through research, it is found that game theory plays an important role in business decision-making, which makes a significant difference in planning the future development path of the enterprise. By using game theory models such as the Prisoner's Dilemma and boxed pigs, entrepreneurs can make optimal business decisions. Through an in-depth understanding of the relevant knowledge of game theory, entrepreneurs can know the timing and maximum benefits of business cooperation and competition, which provides important tips for enterprise reform and development in the new era.

1 Introduction

How to make correct business decisions has become a focus of concern for entrepreneurs. With the continuous development of the times, the business environment has become more and more complex and competitive. The modern business environment is highly competitive and fast-paced. With the development of technology and the drive for globalization, the market has become more complex and diverse. Businesses need to constantly innovate and adapt to change to stay competitive. At the same time, consumer needs and behaviors are constantly changing, and they have higher requirements for product quality, service, and sustainability. In addition, the rise of social media and the Internet has made it necessary for companies to pay more attention to brand image and consumer experience. In this environment, businesses need to be flexible, innovative, and agile to proactively respond to challenges and seize opportunities. In this era of rapid change, making the right business decisions has never been more important. Correct business decisions can help companies seize opportunities, cope with challenges, and achieve sustained competitive advantage. It can not only increase a company's revenue and profits but also improve its reputation and brand image. Wrong business decisions may cause enterprises to face huge risks and losses. Therefore, for enterprises, making correct business decisions is the key to staying competitive and achieving sustainable development. According to the existing literature, the application of game theory in business decision-making is very extensive. Business decisions often involve competition and cooperation among multiple parties, and game theory can help analyse the interests, strategies, and results of each party.

Moreover, game theory provides a theoretical basis and decision-making tools for business decisions, helping companies develop smarter strategies.

However, there is still no unified understanding of the specific mechanism of application of game theory in business decision-making. This article will explore the principles behind using game theory to make correct business decisions and its impact on future enterprise development by exploring two specific game theory problems, the Prisoner's Dilemma and the Boxed Pigs. This article first provides a detailed introduction to the prisoner's dilemma concept and its workings. The application of the prisoner's dilemma to commercial price battles reveals the significance of cooperative efforts and ideal pricing tactics for the sound growth of the business. Additionally, this page describes the concepts and best practices and deduces the full procedure of the boxed pigs. Both large and small and medium-sized businesses have developed distinct business strategies and development plans by examining the corporate innovation ideas offered by the boxed pigs.

In the context of enterprise pricing, for example, the optimal strategy of the Prisoner's Dilemma suggests that a price war must ultimately result in both losers and no winners. Thus, it can be concluded that win-win collaboration is the safest way for firms to profit and that enterprise cooperation is the only option to overcome the price war conundrum. For another, tiny and medium-sized businesses will opt to wait and copy, while huge corporations can only decide to keep innovating, according to the best strategy of the smart pig game. This will ultimately have the effect of making it more

* Corresponding author:smyyx10@nottingham.edu.cn

difficult for small and medium-sized businesses to thrive in the quickly evolving modern world unless they pursue innovative development and implement progressive improvements. Generally speaking, game theory is used to inform business decisions in more ways than just these two. Future investigation and study into company strategies is eagerly anticipated, as is the growth of firms in the future. Game theory techniques for use in corporate decision-making are also anticipated.

2 Application of game theory to business decision-making

2.1. Pricing strategy--price wars

According to the prisoner's dilemma model in game theory, the result of a continuous price war is that both sides will lose, so win-win cooperation is the correct business decision in pricing [1]. The following is the traditional prisoner's dilemma: Although A and B, two suspects, were taken into custody by the police, there was insufficient evidence to prosecute them. Thus, the suspects were detained individually by the police, who also held separate meetings with them and gave them the following options:

• If one pleads guilty and selects "confess" (a term that is connected to "betraying" the other party), and the other selects "don't confess," the guilty party will be released right away and the other will receive a 10-year prison sentence.

• Both of them will receive a one-year prison sentence if they decide to "don't confess" (applicable phrase refers to joint "cooperation").

• Should they both select "confess," they will both receive a six-year prison sentence [2].

Table 1. Prisoner's dilemma's payoff matrix

A / B	don't confess	confess
don't confess	(-1, -1)	(-10, 0)
confess	(0, -10)	(-6, -6)

Table 1 shows the payoff in this prisoner's dilemma. Confess is the dominant strategy among the two strategies. Both players betray each other. As a result, both players serve 6 years in prison. In terms of overall interests, if both participants cooperate and don't confess, both of them will only be sentenced to 1 year in prison. The overall interests are higher, and the result is better than if the two betrayed each other and were sentenced to 6 years in prison. But based on the presumptions mentioned above, it appears that they are both reasonable people who just look out for themselves. Ultimately, both inmates made the decision not to confess. Consequently, the overall advantage was less than that of cooperation, and the verdicts of both inmates were greater than those of cooperation. The "dilemma" is located here [3].

This study now applies the "prisoner's dilemma" model to market rivalry. This study assumed that Suning and JD.com are the only two oligopolistic firms engaged in the price war. They provide consumers with uniform products to grow their market share and profits [4].

Both parties have access to the following four pricing strategies: high-priced, high-priced, low-priced, high-priced, and low-priced, low-priced. This analysis was conducted under the assumption that should JD.com and Suning choose to implement the costly policy, each would be able to generate 100 units of revenue. If both of them choose to adopt low-cost policies, they can each make 70 units of income. The firm that lowers prices can make 150 units of income, whereas the firm that doesn't lower prices can only earn 20 units if one firm chooses high-priced policies and the other takes low-priced policies [5]. The payoff in this price war is demonstrated in Table 2.

Table 2. The price war's payoff matrix

JD.com / Suning.com	high-priced	low-price
high-priced	(100, 100)	(20, 150)
low-price	(150, 20)	(70, 70)

According to "Prisoner's Dilemma"， the dominant strategy for two companies is to continue to reduce prices, which will lead to a loss on both sides compared with both high prices. Therefore, thanks to the prisoner's dilemma of game theory, the right business decision in pricing is cooperation, which can provide an effective and efficient approach for all enterprises to gain collaborative development and common benefits.

2.2 Innovative strategies

Scientific and technical innovation has progressively supplanted conventional production variables like labor and capital in the global framework of world economic globalization and expanding regional economic integration, rising. It is now a crucial foundational resource for business development. Thus, the initial strategic decision should be to center technology innovation on the enterprise's overall development [6]. Based on the smart pig game in game theory, large companies are like big pigs. They invest a lot of money in technological innovation and develop new products, while small and medium-sized enterprises are like small pigs. They may not be able to carry out large-scale technological innovation for a while, but they can adopt a follow-up strategy and wait for big companies to develop new products. When a company's new products open new markets, imitations of large companies' new products begin to be sold [7].

With an exit on one end and a button on the other, the manager is incredibly lengthy. Once the button is pressed, 10 units of food can be obtained, but 2 units of payment are required. Therefore, depending on whether they choose to "press the button" or "wait" in terms of their gambling methods, the outcomes will vary. The small pig can only obtain four food units whereas the

giant pig can receive six when the big pig clicks the button while the small pig waits, however, after subtracting the cost, the big pig can only receive four units. If the big pig waits and the small pig presses the button, when the cost is subtracted, the big and small pigs can receive 9 and -1 units. If they press the button synchronously, when the cost is subtracted, they will receive 5 and 1 units. If neither press the button, there can be zero food available. Here are the specifics of the traditional Boxed Pigs [8]:

Table 3. The boxed pigs' payoff matrix [9]

Big pig \ Small pig	press	wait
press	(5, 1)	(4, 4)
wait	(9, -1)	(0, 0)

Table 3 displays the reward of the big pig as the first component and the payout of the small pig as the second player for each payoff vector. The payoff matrix indicates that "wait" is the small pig's dominant strategy. The big pig's best course of action when the small pig selects "wait" is to "press the button," and thus creates a Nash equilibrium in the game when the big pig clicks the button and the small pig waits [9]. Therefore, the small pig may incur a high cost with a benefit level of -1 if it is unable to accurately assess the circumstances and selects "the button" hastily. When there is unequal bilateral strength, a game theory known as "boxed pigs" is played; the strong player initiates, while the weak player hitches and waits. According to the gambling model, we should choose a betting strategy that suits the situation and the opponents [8].

In the real market, due to the inequality of enterprise strength, or even large differences, different enterprises have different choices of technological innovation strategies - large enterprises have a large market share, and the effect of innovation is more obvious; small enterprises have a small market share, and the motivation for innovation is insufficient. In addition, the size of the enterprise will have a great impact on innovation efficiency. For example, the innovation costs (investment costs and operating costs) of large enterprises are easier to digest than those of small enterprises. Suppose A is a large enterprise and B is a small and medium enterprise. If A's technological innovation contribution rate is higher than B, then the behavior of the smart pig game will occur which is displayed in Table 4 [10].

Table 4. The return matrix of the two enterprises

A \ B	innovate	not to innovate
innovate	(5, 1)	(4, 4)
not to innovate	(9, -1)	(0, 0)

Due to the constraints of scale, capital, talent, risk resistance, and other factors, in the process of competing with large enterprises, small and medium-sized enterprises will not spend money on technological innovation. Instead, they wait for the successful development of new products by large companies and then carry out imitation production. Large companies know that small companies will choose "not to innovate", so they can only choose to "innovate" first. Because of "no innovation", the income is 0. Therefore, the Nash equilibrium currently is (Innovation, not Innovation) [10].

The smart pig game illustrates that when large and small enterprises coexist, only large enterprises have sufficient incentives to carry out technological innovation. And the proactive innovation of large enterprises will lead to the development of an industry [11].

2.3 The solution to price wars

Businesses need to work together to put an end to reckless, harmful competition behavior when it reaches a particular level so that the industry won't suffer from significant losses [12].

For instance, in the building industry, there is a distinct perception that quality generally comes at a lower cost. In the slim chance that they may be awarded a contract, contractors often rush to the bottom with their prices, and tender quotes are not thoroughly investigated. Roberts feels that charging less than what is required for the job will ultimately leave the trader and the consumer out of money, notwithstanding this incentive. However, if subcontractors cooperate and allocate resources reasonably, a win-win situation will be formed. There is evidence to suggest that subcontractor earnings increased in 2019 by up to 7%, which is three times the annual rate of inflation. Regrettably, some subcontractors tarnish this by underselling themselves and putting themselves in a lose-lose scenario. Not only do they lose out on possible higher income, but by underselling and producing mediocre work for clients, they damage the industry's worth and reputation overall [13].

In conclusion, if the company's strategy is known to competitors and it should be clear to competitors that the company is prepared to cooperate but will retaliate against betrayal, then the company will ultimately win the competition and the gains from cooperation will be large. Companies may significantly lower the likelihood of damaging competition, such as price wars, by thoroughly analyzing the competition, accurately predicting its potential responses, and having a desire to collaborate and share.

2.4 The solution of Innovative strategies

According to the conclusion of the smart pig game theory, the best strategy for small businesses is to wait. However, practice tells us that this is only a theoretical optimal, and rational choice. In fact, due to the influence of many factors such as internal and external environment, for many small businesses, this passive waiting is not the best choice [14].

Firstly, small and medium-sized enterprises should promote innovation through imitation.

In the process of imitation, small and medium businesses should gradually digest and absorb advanced technologies, through which they can improve the

market competitiveness of our products, strengthen, and develop corporate strength, and lay the foundation for independent innovation. Don't just be satisfied and simply imitate, they should set their goal to catch up with the pioneers. Given that small and medium-sized enterprises are weak and have insufficient innovation resources, small and medium businesses can form strategic alliances with other enterprises, taking advantage of each other's advantages to jointly develop new technologies, share risks, and benefit from each other. Additionally, Small and medium-sized enterprises must clarify their market positioning. In the boxed pigs model, the best strategy adopted by small pigs is to wait, so small and medium businesses position themselves in the market. In terms of marketing strategy and marketing mix, small and medium-sized enterprises should keep a certain distance from companies that are pioneers in technological innovation and should not follow too closely. Otherwise, it will trigger a counterattack from large companies. If large companies react violently, they may suppress imitation innovators in all aspects. On the other hand, the early preparation of large enterprises in the market can save imitators a lot of market cultivation and development costs, and followers can also learn from their experiences and lessons [15].

In a word, small and medium-sized enterprises should reposition themselves and unswervingly pursue an independent innovation path, through which they can transform the enterprise development model, and use technological progress to solve resource and cost bottlenecks that restrict enterprise development [16].

3 Conclusion

In conclusion, this study found that game theory can help entrepreneurs make correct business decisions, not only in terms of business cooperation and business competition but also in terms of future reform and development of enterprises. First of all, this article introduces the principle of the prisoner's dilemma and its operating mechanism in detail. By studying the application of the prisoner's dilemma in commercial price wars, the importance of optimal pricing strategies and cooperation for the healthy development of business is discovered. Besides, this article completely deduces the entire process of the boxed pigs and explains the principles and optimal strategies. By exploring the strategies provided by the boxed pigs for corporate innovation, large enterprises, and small and medium businesses have obtained different business strategies and development plans. Additionally, this article infers two important strategies for enterprise development by studying the conjecture of the Prisoner's Dilemma strategy on the consequences of price wars and the impact of the Boxed Pigs strategy on the corporate innovation market. For one thing, according to the optimal strategy of the Prisoner's Dilemma, it can be inferred that in enterprise pricing, the result of a price war must be that both losers and no one can benefit. Therefore, it can be inferred that enterprise cooperation is the only way to break through the dilemma of price war, and win-win cooperation is the safest way for enterprises to benefit. For another, according to the best strategy of the smart pig game, large enterprises can only choose to continue to innovate, while small and medium-sized enterprises will choose to wait and imitate. In the long run, the consequence of this is that it will be difficult for small and medium-sized enterprises to survive in today's rapidly developing era unless they make gradual changes and seek innovative development. In general, the application of game theory in business decision-making is not only reflected in these two aspects. More business strategies are waiting for future exploration and research, and the future development of enterprises is waiting for more game theory strategies to be applied in corporate decision-making.

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