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Modelling corporate rivalry using game theory: Pliva vs. JGL

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Abstract

This paper applies game theory to model and analyze the competitive dynamics between two leading Croatian pharmaceutical firms, Pliva Hrvatska d.o.o. and Jadran - galenski laboratorij d.d. (JGL). The primary objective is to assess the strategic interactions between companies through a formalized game-theoretic framework, with particular emphasis on the concepts of Dominant strategies, Nash equilibrium, and the Prisoner's dilemma. Using financial and operational data from 2019 to 2023, the study constructs payoff matrices under two scenarios: with and without the inclusion of innovation costs. The analysis reveals that while innovation is a Dominant strategy for both firms, asymmetric firm size and cost structures significantly affect profitability, with Pliva able to absorb innovation costs more sustainably. However, the absence of a pure Nash equilibrium and the presence of a Prisoner's dilemma highlight the tension between cooperation and competition. The findings underscore the strategic value of differentiation and innovation, particularly in oligopolistic markets with high entry barriers.

Keywords: game theory, Nash equilibrium, Prisoner's dilemma, pharmaceutical industry, corporate strategy

1. Introduction

Looking at everyday aspects of life and life situations, we use different strategies in our interactions with other people. In various situations, from family disputes, decisions about buying a car or a house, the use of certain resources in production or production strategies, we can see the application of game theory. Game theory is used in a very wide range of applications because it gives us guidelines for choosing the best strategies in interactions in which the outcome for us is conditioned not only by our actions, but also by the actions of others. It is these guidelines that individuals, companies, employers, unions, athletes, politicians, governments, non-governmental organizations and the community are guided by when they face competition or conflict. However, besides competitive situations, game theory also deals with cooperation in situations when it is necessary to find an answer to important questions of sociologists, psychologists, economists or political scientists. Game theory is a mathematical discipline that is found in some segments of everyday life (Kopal and Korkut, 2011). In economics, it is applied in the stages of making business decisions, in hostile takeovers of companies, determining prices in relation to competitors, capturing market share, etc. It serves as a tool in designing a business strategy because it shows economic situations very well.

Through this paper, game theory will be applied in the analysis of the relationship between the two competing companies, Pliva and JGL. By reviewing and analyzing the income and net profit of the mentioned companies, the possibilities for growth and development strategy will be explored through the game theory model with an emphasis on Nash equilibrium, Dominant strategy and Prisoner's dilemma. Given that both companies are among the leaders in the domestic and foreign pharmaceutical market, have recorded revenue growth for the past several years with high investments in research and development, we will try to gain insight into their business strategies.

2. Literature review

Game theory has become a central analytical framework in industrial organization and strategic management, offering a structured method for examining the behavior of firms in competitive settings. Particularly in oligopolistic markets such

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as the pharmaceutical sector, game-theoretic models are instrumental in evaluating the effects of strategic decisions, including pricing, innovation, R&D investments, and market entry or exit.

In the absence of similar research and/or methodological parallels, this section will present several relevant and recent studies that examine strategic relationships in game theory and/or the pharmaceutical industry. Tirole's (1988) seminal text lays the theoretical foundation for understanding firm behavior in imperfectly competitive markets. He systematically applied game-theoretic logic to model pricing strategies, barriers to entry, and R&D, key themes relevant to the pharmaceutical industry. His discussion of repeated games and credible threats is particularly applicable to long-term rivalries like those between Pliva and JGL. Shapiro (1989) argued that strategy should be defined in terms of game-theoretic commitments. He examined how firms leverage irreversible investments and pricing to deter rivals highly relevant to the innovation vs. stable growth strategies modeled in our research.

Goeree and Holt (2001) presented real-world inconsistencies in game-theoretic predictions, including examples from industrial competition. It underlines the importance of empirical validation of strategic models, such as the one used in the Pliva-JGL analysis. Hausken and Ncube (2022) developed a complex game-theoretic model consisting of three interlinked games involving individuals, vaccine and drug companies, a donor, and nature to simulate decision-making during an infectious disease outbreak. Each of the 14 possible outcomes is shaped by probabilistic events, costs, and strategic choices, such as whether to engage in risky behavior, produce vaccines or drugs, or subsidize their development and purchase. The model demonstrates how changing conditions, such as infection probabilities, side effects, prices, and donor support, alter the incentives for individuals and companies, and offers insights for improving pandemic management and public health strategy. Kazuhiro and Nobuo (2021) evaluated how entrant firms strategically select partners (e.g., distributors) to penetrate a market. They developed a game-theoretic entry model with duopolistic incumbents, analogous to pharmaceutical firms choosing collaboration channels. Mostofi et al. (2023) integrated game theory and data science to address quality degradation and regulatory compliance in supply chains in Iran. Authors found that firms choose investment levels and enforce standards, modeled in a strategic game framework. Wang et al. (2024) analyzed the strategic interactions between pharmaceutical companies, auditing organizations, and health insurance regulators in China using an evolutionary game theory model. The authors found that effective governance can be achieved when companies comply with regulations, auditors reject bribes, and regulators adopt moderately lenient oversight. The research emphasized the importance of coordinated strategies and policy adjustments to reduce corruption and support sustainable development in the pharmaceutical industry.

3. Pharmaceutical industry market

The pharmaceutical industry is a branch of the chemical industry whose main activity is the production of pharmaceutical raw materials, finished medicines and medicinal preparations, and it represents one of the most profitable industries due to the results achieved, the number of employees in this industry and constant investments in research and development and the high number of exports, and as such it represents one of the important backbones of economic development in Croatia. Over the past few decades, the global pharmaceutical industry has experienced rapid development, but despite this, regulatory changes, product withdrawals from the market, patent expiration and poor distribution channels have put the sustainability of the pharmaceutical market under the public's scrutiny. Due to a long-standing and very expensive process marked by ups and downs, the pharmaceutical industry is a specific industry branch that is also associated with negative public perceptions as an industry motivated by profit. This is evidenced by the fact that the pharmaceutical industry is one of the most profitable and fastest growing industries on a global level, which has shown strong resilience even in times of global crisis precisely because of the human need to preserve the quality of life. More than 160 pharmaceutical companies operate worldwide, and in 2020, the 50 largest generated a combined revenue of \$851 billion (Insolve.hr, 2025).

The pharmaceutical industry in Croatia is of great importance for economic development, requiring coordination between governments, ministries and other stakeholders. The largest companies include PLIVA, Belupo, JGL, PharmaS, Hospira Zagreb d.o.o., Genera d.d., Krka-Farma d.o.o., Fidifarm d.o.o., Apipharma d.o.o. and BioGnost d.o.o. Among the foreign companies operating in Croatia, GlaxoSmithKline, Hospira, Galapagos Research Center, ACG Lukaps, Farmal and others are significant. In 2020, the total pharmaceutical industry in the Republic of Croatia generated 985 million euros in revenue, of which 73% was exported (Financial club, 2021). Pharmaceutical companies require highly educated staff, quality and experienced workers, experts and scientists due to continuous research and confidentiality of the data they work on. The Croatian pharmaceutical industry market is characterized by an oligopolistic market in which a few companies control the majority of the market share. The entry of new companies into the market is extremely difficult due to the high costs of establishing a production facility, the high investments in research and development that the industry requires, investments in marketing and distribution, and the indispensable employment of quality personnel. The risk of new companies losing their investment is high if production criteria are not met on time. Croatia is experiencing an increase in the number of pharmaceutical companies and the development of the pharmaceutical industry. The above-mentioned companies have developed economies of scale which ensure the realization of profits, and there is no high threat of new competition entering the market due to the long process of approval by regulatory authorities, gaining trust from customers and obtaining patents for a new product.

Table 1. Top ten pharmaceutical manufacturers in Croatia in 2019 according to business performance indicators

	Total revenues (in million euros)	Index 2019/2018 (in %)	Debt ratio (in %)	Current ratio (in %)	Gross margin (in %)
Pliva Croatia d.o.o.	632.76	15.59	0.24	1.7	24.63
Belupo d.d.	96.09	13.79	0.28	3.0	12.22
JGL d.d.	76.44	16.68	0.45	2.7	13.32
Hospira Zg. d.o.o.	47.94	13.48	0.15	3.2	12.28
Genera Inc.	31.8	16.06	0.57	2.7	9.58
PharmaS d.o.o.	28.59	17.72	0.68	1.5	6.08
Krka-Farma d.o.o.	21.85	12.48	0.05	6.8	4.03
Fidifarm d.o.o.	13.1	12.94	0.22	3.3	29.09
Apipharma d.o.o.	4.45	25.34	0.59	1.6	39.87
BioGnost d.o.o.	4.33	11.70	0.45	1.7	4.45

Source: EIZG, 2020.

Table 1 displays business performance indicators for these top ten companies. The current liquidity ratio, whose value for neither of the companies is below the minimum acceptable limit of 1.5, shows that each of the listed companies has a satisfactory ability to settle its short-term liabilities. In relation to indebtedness, most companies have good indicators. The highest gross margin in 2019 was recorded by Apipharma, Fidifarm and Pliva.

4. Competitive dynamics between Pliva and JGL: A game theory perspective

After gaining insight into the operations of both companies, Pliva and JGL, and understanding their behavior and performance on the market, based on data from Table 1, we will build a payoff matrix using game theory and analyze:

- Nash equilibrium,
- Dominant strategy and
- Prisoner's dilemma.

For example, in 2020, the pharmaceutical sector in Croatia generated a total of 984,884,720 euros in revenue, of which 60.54% belonged to Pliva and 8.22% to JGL. Through the next two tables we will analyze relevant business performance indicators for both companies.

Table 2. Overview of business performance indicators for Pliva in the period 2019 - 2023 (in EUR)

Indicator	2019	2020	2021	2022	2023
Business income	626.222.457	583.035.132	613.724.502	641.491.727	719.247.890
Business expenses	472.414.464	485.546.531	505.484.857	523.854.941	587.129.515
Raw material and material costs	165.731.988	188.497.006	197.724.970	184.938.784	209.676.877
Share of total costs of raw materials and supplies in total expenses (%)	34.75	37.78	38.85	34.51	33.25
Financial income	6.533.869	13.213.441	11.299.906	16.308.555	10.868.390
Financial expenses	4.503.367	13.287.036	3.460.281	12.002.102	43.528.316
Total revenues	632.756.623	596.248.573	625.024.408	657.800.282	730.116.280
Total expenses	476.917.831	498.833.567	508.945.138	535.857.043	630.657.831
Net profit	130.656.086	110.508.703	95.566.278	110.893.645	79.577.113

Source: Poslovna Hrvatska, 2024.

Table 3. Overview of business performance indicators for JGL in the period 2019 - 2023 (in EUR)

Indicator	2019	2020	2021	2022	2023
Business income	73.136.310	77.714.084	93.306.066	107.075.828	132.073.576
Business expenses	62.281.112	66.211.865	74.812.202	88.033.821	113.692.889
Raw material and material costs	19.616.108	26.465.870	24.948.431	31.261.002	43.525.544
Share of total costs of raw materials and supplies in total expenses (%)	29.61	36.34	32.00	31.07	36.05
Financial income	3.300.808	3.212.105	2.412.239	7.998.410	1.608.015
Financial expenses	3.972.245	6.611.417	3.236.828	12.574.892	7.039.867
Total revenues	76.437.118	80.926.189	95.718.304	115.074.238	133.681.591
Total expenses	66.253.357	72.823.282	78.049.030	100.608.713	120.732.756
Net profit	10.336.013	8.773.780	16.783.883	15.664.780	13.084.736

Source: Poslovna Hrvatska, 2024.

Tables 2 and 3 display the structure of total revenues and total expenses for Pliva and JGL and their net profit. Namely, both companies are dependent on the Far East markets in terms of purchasing raw materials and materials due to the lack

of availability of raw materials on European markets, and changing suppliers is a very expensive and time-consuming process. Personnel costs as part of operating expenses also account for a large share, given that the employees of both companies are predominantly highly educated personnel and that the average salary in Pliva in 2022 was 2,920 euros, and the number of employees has grown in previous years (Poslovna Hrvatska, 2022). Both companies are exposed to the risk of foreign currency exchange rates during procurement and sales, given that most products are intended for export. The introduction of the euro as the official currency in the Republic of Croatia significantly reduced the risk in 2023, but the risk of exchange rate changes in relation to the Russian ruble and the US dollar remains, so financial expenses, among other things, are a large part of total expenses. The framework of the game will be set on the basis of data on the change in revenues between 2019-2023 for the Pliva and JGL, as seen in Table 4.

Table 4. Change in revenue of Pliva and JGL compared to the previous year

	Change in Pliva's revenue	Change in JGL's revenue
2020	-5.77%	+5.87%
2021	+4.83%	+18.28%
2022	+5.24%	+20.22%
2023	+11%	+16.17%

Source: Author's calculations.

Framework of the game:

(1) Players

Pliva Croatia Ltd and JGL are two competing firms in the Croatian pharmaceutical industry. Their goals are conflicting, as both seek to increase their market share in a limited market, any gain by one firm reduces the potential share for the other.

- Pliva – a dominant player with greater financial capacity, focused on generic drugs and exports.
- JGL – a smaller but specialized company with a strong presence in niche segments (ophthalmology, ENT, dermatology).

Strategies (strategy space):

Let us define the Cartesian product of strategies for both players as:

- $S_i = \{I, S\}$
where:
I – innovation/differentiation strategy (high investment, high risk, high growth potential)
S – stable growth strategy (risk-averse, cost optimization)

The Cartesian product of strategic choices is:

$$S_{Pliva} \times S_{JGL} = \{(I,I), (I,S), (S,I), (S,S)\} \quad (1)$$

(2) Rules

(a) Timing:

The game is simultaneous—both companies make strategic choices at the same time, without knowing the other player's decision.

(b) Available actions:

- Innovation (I): investment in new technologies, production facilities, and products.
- Stable growth (S): focus on existing operations, cost efficiency, no aggressive expansion.

(c) Information:

Players have complete information regarding historical data, financial performance, and strategic options, but imperfect knowledge about the opponent's actual strategy in the current round.

(3) Outcome and payoffs

The outcome depends on the combination of strategies chosen. Results are expressed in either market share change (in the basic game) or net financial gain in millions of euros (in the modified game including innovation costs).

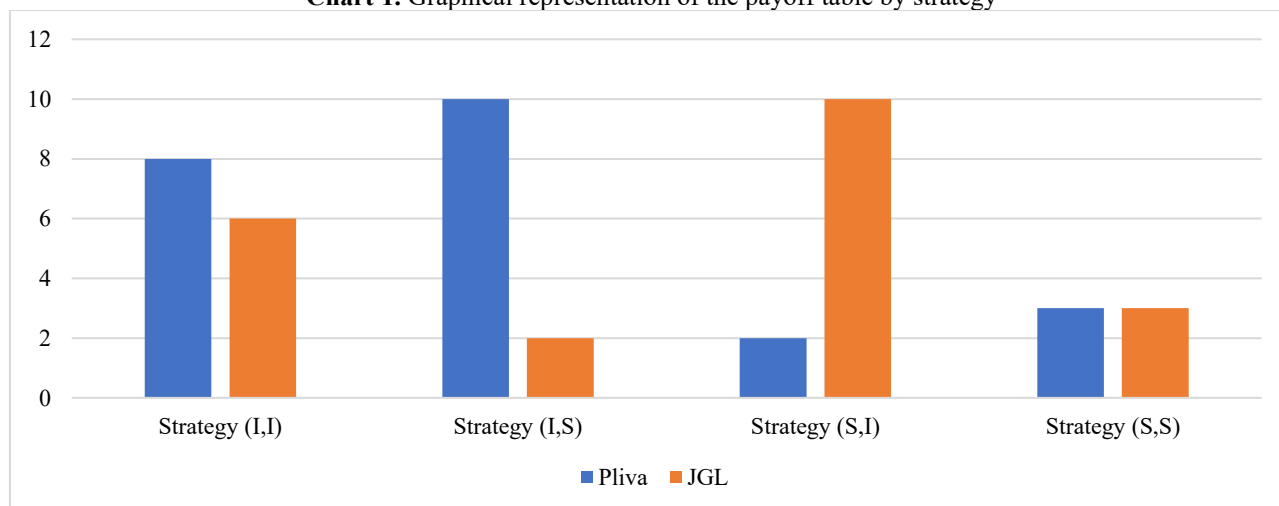
Table 5. Payment table based on performance indicators of Pliva and JGL

	JGL: Innovation (I)	JGL: Stable growth (S)
Pliva: Innovation (I)	Pliva: +8% market share JGL: +6% market	Pliva: +10% of the market JGL: +2% market
Pliva: Stable growth (S)	Pliva: +2% market share JGL: +10% market share	Pliva: +3% market share JGL: +3% market

Source: Authors' calculations

Explanation (Table 5):

- If both companies decide on an innovation strategy and invest aggressively (I,I) both companies grow (+8%, +6%) but at high costs and high risk. Companies can become too exhausted in this strategy and reduce profitability due to costs.
- If Pliva opts for an innovation strategy (I) and JGL opts for a stable growth strategy (S), Pliva will grow strongly and dominate the innovation market (+10%), while JGL will progress slightly (+2%). This is where the biggest gain is for Pliva.
- If Pliva opts for stable growth (S) and JGL invests aggressively in innovation (I), the growth potential is greater for JGL (+10%) and it takes Pliva's market share, but at high risk and high costs. Pliva, in this case, achieves stable growth (+2%).
- If both companies decide for stable growth (S,S), both 'play it safe', maintain their existing positions, but without significant changes.

Chart 1. Graphical representation of the payoff table by strategy

Source: Authors' calculations.

Dominant strategy as a strategy that brings the best result regardless of what the other company is doing based on the previous matrix and Chart 1:

For Pliva:

- If JGL innovates → Pliva gets +8% with innovation, only +2% with stable growth.
- If JGL remains on a stable growth path → Pliva gains +10% through innovation, +3% through stable growth.

According to the above, the Dominant strategy for Pliva is Innovation (I), which can increase market growth because regardless of which strategy JGL chooses, Pliva achieves better results through innovation.

For JGL:

- If Pliva innovates → JGL gains +6% with innovation, only +2% with stable growth.
- If Pliva goes for stable growth → JGL with innovation +10%, with stable growth +3%.

For JGL, the Dominant strategy is also Innovation (I) because, regardless of Pliva's strategy, market share growth is greater in this strategy.

A Nash equilibrium occurs when neither player has an incentive to change their strategy unilaterally. It is realized in a combination of strategies when Pliva Innovates and JLG Innovates (I, I) because Pliva has no motivation to move away from innovation, even if JGL changes its strategy. If Pliva switches to a strategy of stable growth without innovating, it would drop from +8% to +2%, which is not the company's goal if it wants to advance in the market.

Prisoner's dilemma:

The options for both players are:

- possibility of cooperation or betrayal (uncooperative behavior),
- cooperation of both players, leading to a better result for both,
- the betrayal of one player while the other player cooperates, whereby the traitor profits and the collaborator lose,
- betrayal by both players, leaving both sides worse off than if they had cooperated.

If we view the given strategies by Pliva and JGL as:

- Innovation = "betrayal" (aggressive expansion, market attack, expense)
- Stable growth = "cooperation" (peaceful market sharing, lower costs)

we obtain the following model of the Prisoner's dilemma.

As a result of the dilemma (Table 6), we see that if both firms innovate (I, I), due to high costs, both will achieve a lower net profit than if they had cooperated (steady growth, S, S). However, the factor of fear that the other player will innovate forces both companies to innovate so as not to find themselves in a disadvantageous position. The rational behavior of both players ultimately leads to a worse outcome due to high innovation costs and market exhaustion. If the companies reached an agreement, they would both remain at stable growth (+3%), but considering that there is mistrust and pressure on the market, both companies are going to innovate. In this case, Pliva, as a larger player, bears less risk and benefits more from innovation than JGL.

Table 6. Overview of the Prisoner's dilemma Model

	JGL: Stable growth (S)	JGL: Innovation (I)
Pliva: Stable growth (S)	Both companies have stable growth and secure profits.	JGL gains advantage through innovation; Pliva lags.
Pliva: Innovation (I)	Pliva takes over the market with innovation; JGL loses part of the market.	Both firms innovate, high costs for both firms, market growth for both firms, lower net profit.

Source: Authors' compilation

Based on the data from the payoff table, we will include innovation costs and present a new modified payoff matrix (Table 7), for Pliva and JGL. If we assume that Pliva spends around 50 million euros per year on innovation (average according to investments in research and development, new production facilities and solar power plants) (Pliva.hr, 2024), while JGL spends around 20 million euros (Integra project, sterile facilities, distribution center) (jgl.hr, 2024) we will include investment cost indicators in the new payoff table, which changes the companies' net profit.

Market share gains - approximately 1% market share brings:

- for Pliva 7 million euro profit,
- for JGL 1.3 million euro profit.

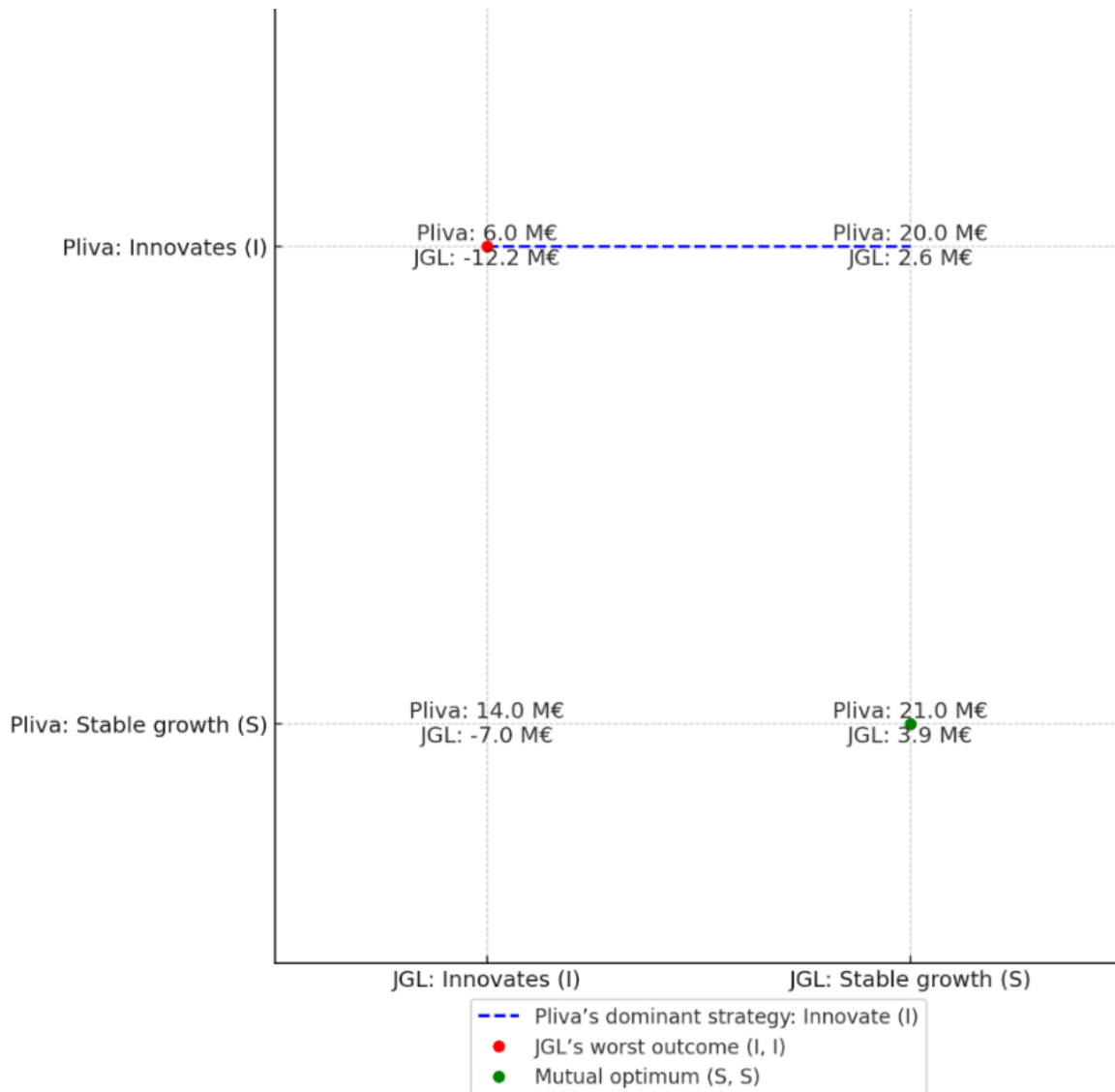
Table 7. Modified payoff table with innovation costs

	JGL: Innovates (I)	JGL: Stable growth (S)
Pliva: Innovates (I)	Pliva: $-50 + (8 \times 7) = 6$ JGL: $-20 + (6 \times 1.3) = -12.2$	Pliva: $-50 + (10 \times 7) = 20$ JGL: $0 + (2 \times 1.3) = 2.6$
Pliva: Stable growth (S)	Pliva: $0 + (2 \times 7) = 14$ JGL: $-20 + (10 \times 1.3) = -7$	Pliva: $0 + (3 \times 7) = 21$ JGL: $0 + (3 \times 1.3) = 3.9$

Source: Authors' calculations

Explanation (Table 7):

- The results obtained represent an additional net profit or loss according to the market share gained in millions of euros.
- If both Pliva and JGL decide not to innovate (S,S) Pliva achieves the highest growth in this strategy (21 million euro) because there is no investment cost – the highest payout for Pliva.
- If Pliva innovates while JGL innovates at the same time, the high cost of innovation results in an additional net loss for JGL (-12.2 million euro) – the lowest payout for JGL.
- Nash equilibrium – there is no pure equilibrium.

Chart 2. Graphical representation of the relationship from the modified payoff table with innovation costs

Source: Authors' calculations

The strategy of non-innovation, or stable growth (S,S), is the only combination in which both firms achieve the best result and neither company can improve its result by unilaterally changing its strategy. Here we see elements of Nash equilibrium, but in the long term it is not a sustainable strategy for Pliva due to stagnation, or a decline in net profit over the past five years, and high expenses that reduce net profit. Although Pliva gains 3% of the market with this strategy, and each market expansion requires some activity, the same growth could be attributed to aggressive marketing, price reductions or strengthening distribution. The Dominant strategy for Pliva (Chart 2) would be to innovate (I) because only in this way can Pliva expand the market, which is the most sustainable strategy in the long term, and with this strategy Pliva gains only one additional million euros less than with the strategy of non-innovation (S).

5. Payoff dynamics across strategic alternatives

Due to the size of Pliva, it would seem that the company has no competition on the domestic market, but its stagnant revenue calls into question the above. Pliva has announced changes in business strategies in the form of investments in sterile production and expansion of the production process to the production of injections, or foams, which would provide the company with an opportunity for profit and expansion into global markets. By investing intensively in innovative production, Pliva, as a member of the Teva Group, could use its resources to further invest in the research and development of new innovative drugs where competition is not strong. We have investigated the results of this possibility of investing in innovation through the Innovation strategy in this paper and obtained confirmatory results. Namely, we have seen that in the case of choosing an innovation strategy and aggressive investment, Pliva would achieve market share growth (of 8 or 10%), regardless of JGL's decisions, but with high costs and the high risk that innovation bring. The same strategy also represents a Dominant strategy for Pliva precisely because of its independence from JGL's decisions. Although the costs

of such strategies are very high, they are often highest in the first year, so the strategy may seem unprofitable, but in the long term, Pliva needs a new business strategy precisely because of the decline in net profit.

We analyzed how successful this strategy would be through a payoff table, considering the investment costs, which are very high in the pharmaceutical sector. If Pliva were to innovate, it would achieve an additional net profit of 6 or 20 million euros, depending on JGL's strategy. Due to the large difference in the value of the potential profit achieved, there is no pure Nash equilibrium, so we cannot say that JGL does not influence the outcome of Pliva's strategy with its decisions. Innovation as an investment can often seem unprofitable in the first year, but Pliva, as a larger company with large resources and revenues, can bear such a financial risk and distribute the investment costs across the entire business. On the other hand, for JGL, the innovation strategy represents a major financial risk that reduces profitability, resulting in a net financial loss of -12.2 or -7 million euros depending on Pliva's strategy, which indicates that JGL, due to its smaller business scope, must carefully choose what and when to innovate. Pliva, as part of Teva, would strengthen exports to the USA, which has the most developed market for injectable drugs and devices such as pens, with such a strategy, and in 2023, the USA holds the largest share of the global market for injectable drug delivery systems, with a share of 51.9% (BioSpace, 2024). With its 90% export of goods and revenues of 730 million euros, Pliva is already near the top and dominates the pharmaceutical industry, and the room for growth is smaller than in comparison to JGL, which is 5-6 times smaller than Pliva, and as a smaller player and at a lower level, it is easier for it to achieve faster growth. It may seem that JGL does not compete with Pliva due to its size, but in the oligopolistic market, JGL, with its branded products (Aqua Maris, Vizol, Meralys), prevents other companies, including Pliva, from copying, thus taking a share of the market for itself. JGL, as well as other smaller companies, maintain market competition, especially in the Croatian market, the markets of Bosnia and Herzegovina, Serbia and Slovenia.

Given that Pliva dominates the generic market, without smaller companies like JGL, Pliva would have a monopoly in some segments, such as prescription drug sales. In the race for profit, the best strategy for JGL would be to focus on innovation in which Pliva is not present and step out of the "shadow" of a large company, thereby reducing the risk of innovation. By focusing on innovation in niche segments such as ophthalmology, for which it is recognized on the domestic and wider market (Aqua Maris, Vizol), and the areas of dermatology and gastroenterology, JGL would greatly reduce the cost of investment and increase the potential for differentiation, and avoid high costs. The prices of generic drugs that Pliva is focused on have been under pressure for several years, which limits Pliva's profits and, by withdrawing products from the market due to the unprofitability of their production, leaves end consumers in disbelief and dissatisfaction. With the cooperation of both companies, stable growth would be the best option for both Pliva and JGL, which would achieve more stable profits, but the fear of innovation and distrust among competitors "push" both companies to innovate and thus risk high costs and consequently lower net profits. Here we see elements of the prisoner's dilemma, according to which the fear of falling behind pushes both companies to make expensive investments, although cooperation would bring better results. In accordance with all the above, we can conclude that in the competition between Pliva and JGL, game theory shows that innovation is the Dominant strategy for both companies, but due to the disproportionate strengths of the companies, Pliva, as the larger company, has a significant advantage.

6. Conclusion

This paper offers a comprehensive and analytically rigorous exploration of strategic interaction in the Croatian pharmaceutical industry through the lens of game theory. Specifically, it models the competitive dynamics between two major firms, Pliva and JGL, using key theoretical constructs such as Dominant strategies, Nash equilibrium, and the Prisoner's dilemma. The primary objective of the paper is to determine which strategic choices, innovation or stable growth are optimal for each firm, given their respective market positions, financial capacities, and competitive incentives. Through a detailed payoff matrix supported by real financial data from 2019 to 2023, the study concludes that while innovation is the Dominant strategy for both firms, it carries asymmetric costs and risks. Pliva, as the larger and financially more robust firm, can absorb innovation-related costs more effectively and thus gains relatively more from aggressive strategies. JGL, on the other hand, faces significant financial strain when opting for innovation, which can lead to net losses in scenarios where Pliva also pursues innovation.

One of the key conclusions of the study is that the absence of a pure Nash equilibrium and the manifestation of a Prisoner's dilemma reflect the complex trade-off between cooperation and competition. Both companies would benefit most from mutual restraint and stable growth strategies, yet the fear of losing market share and the lack of trust push them toward costly innovation. This dynamic is emblematic of many real-world oligopolistic markets, where rational decisions made in isolation lead to suboptimal collective outcomes. The paper successfully demonstrates how game theory can be applied not only to abstract strategic modeling but also to empirically grounded industry analysis, making its conclusions particularly valuable for corporate strategists and economic policymakers.

Among the advantages of the paper is its clear methodological structure, combining theoretical modeling with concrete financial data to enhance the realism and applicability of its findings. The integration of innovation costs into the payoff matrix adds another layer of depth, helping bridge the gap between theoretical equilibrium models and real-world financial consequences. Furthermore, the paper provides an interpretation of how firm size, market segmentation, and

financial capacity influence strategic behavior in oligopolistic settings. However, there are certain limitations that merit attention. The model assumes simultaneous decision-making and perfect knowledge of past performance, but it does not account for dynamic adjustments or repeated interactions, which are common in real markets. The analysis is also limited to two players, omitting the influence of other competitors, regulatory interventions, and consumer preferences, which could alter strategic incentives. Furthermore, while the innovation costs are estimated and included, future cash flows, return on investment, and time-to-market dynamics are not fully considered, which may impact the long-term accuracy of the conclusions. Future research should extend this modeling framework to include dynamic or repeated games, possibly integrating stochastic elements or incomplete information to better reflect market uncertainties. Incorporating additional firms and regulatory actors would also enhance the realism and policy relevance of the model. Furthermore, comparative studies across countries or regions could reveal how institutional environments affect the strategic calculus of pharmaceutical firms.

The relevance of the paper's conclusions extends beyond the specific case of Pliva and JGL. It highlights critical insights for the pharmaceutical industry at large, particularly the tension between innovation and profitability in a competitive, regulation-intensive environment. From an economic standpoint, the study offers a valuable contribution to industrial organization theory, showing how game theory can illuminate the strategic foundations of competition and cooperation, particularly in high-stakes sectors driven by innovation, intellectual property, and global market forces.

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