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GAMING IN UKRAINE THROUGH THE LENS OF APPLIED MATHEMATICS AND STATISTICS

The rapid growth of digital technologies in Ukraine has significantly influenced the dynamics of the gaming industry. With more than 31.5 million internet users and 21.6 million active social media accounts, Ukraine provides a fertile ground for the expansion of online gaming and e-sports ecosystems. Previous research has demonstrated that digital infrastructure and user behavior are closely interrelated with gaming activity levels. However, quantitative models that approximate these relationships at the regional level remain limited. This study offers a simplified regression-based approach to estimate how internet penetration and 4G coverage influence the share of active.

To illustrate the approach, two regions with contrasting infrastructure levels were compared: Kyiv region (72 subscribers per 100 inhabitants, 95% 4G coverage, 25% gamers) and Ivano-Frankivsk region (55 subscribers per 100 inhabitants, 86% 4G coverage, 17% gamers). This model suggests that each additional internet subscriber per 100 inhabitants increases the gamer share by about 0.47%, while each additional percentage point of 4G coverage adds approximately 0.89%.

This regression analysis underscores the importance of digital infrastructure in shaping the gaming landscape in Ukraine. Although the model overestimates actual values due to insufficient observations, the estimated coefficients clearly demonstrate that both internet subscriber density and mobile coverage exert a strong positive effect on gamer participation. The findings suggest that more granular, region-level datasets—combining official statistics, platform-based activity data, and survey responses—are essential for building robust predictive models. Future research should expand the dataset, refine the regression specification, and account for additional explanatory variables such as demographic structure, income levels, and cultural preferences. Such an approach would provide a more comprehensive understanding of the determinants of gaming activity in Ukraine and strengthen the evidence base for digital economy studies.

Keywords: *Gaming in Ukraine, Applied mathematics, Statistical modeling, Internet penetration, 4G coverage, Regression analysis, Digital economy.*

JEL classification*: Z32.*

ГЕЙМІНГ В УКРАЇНІ КРІЗЬ ПРИЗМУ ПРИКЛАДНОЇ МАТЕМАТИКИ ТА СТАТИСТИКИ

Швидке зростання цифрових технологій в Україні суттєво вплинуло на динаміку ігрової індустрії. Маючи понад 31,5 мільйона користувачів Інтернету та 21,6 мільйона активних акаунтів у соціальних мережах, Україна забезпечує благодатний ґрунт для розширення екосистем онлайн-ігор та кіберспорту. Попередні дослідження показали, що цифрова інфраструктура та поведінка користувачів тісно пов'язані з рівнем ігрової активності. Однак кількісні моделі, які наближено описують ці взаємозв'язки на регіональному рівні, залишаються обмеженими. Це дослідження пропонує спрощений підхід на основі регресії для оцінки того, як проникнення Інтернету та покриття 4G впливають на частку активних користувачів. Для ілюстрації підходу було порівняно два регіони з різним рівнем інфраструктури: Київську область (72 абоненти на 100 жителів, 95% покриття 4G, 25% геймерів) та Івано-Франківську область (55 абонентів на 100 жителів, 86% покриття 4G, 17% геймерів). Ця модель показує, що кожен додатковий абонент інтернету на 100 жителів збільшує частку геймерів приблизно на 0,47%, тоді як кожен додатковий відсотковий пункт покриття 4G додає приблизно 0,89%.

Аналіз демонструє потенціал методів регресії для виявлення спрямованих зв'язків між цифровою інфраструктурою та впровадженням ігор. Навіть за попередніми даними результати підтверджують, що проникнення інтернету та покриття мобільної мережі позитивно корелюють з поширеністю ігор в Україні.

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Цей регресійний аналіз підкреслює важливість цифрової інфраструктури у формуванні ігрового ландшафту в Україні. Хоча модель завищує фактичні значення через недостатню кількість спостережень, оцінені коефіцієнти чітко демонструють, що як щільність інтернет-абонентів, так і мобільне покриття мають сильний позитивний вплив на участь гравців. Результати дослідження свідчать про те, що більш детальні набори даних на регіональному рівні, які поєднують офіційну статистику, дані про активність на основі платформ та відповіді на опитування, є важливими для побудови надійних прогностичних моделей. Подальші дослідження повинні розширити набір даних, уточнити специфікацію регресії та врахувати додаткові пояснювальні змінні, такі як демографічна структура, рівень доходів та культурні уподобання. Такий підхід забезпечить більш повне розуміння детермінант ігрової активності в Україні та зміцнить доказову базу для досліджень цифрової економіки.

Ключові слова: *геймінг в Україні, прикладна математика, статистичне моделювання, інтернет-проникнення, покриття 4G, регресійний аналіз, цифрова економіка.*

Problem Statement. The rapid expansion of the global gaming industry highlights the need to better understand the factors influencing gaming adoption at national and regional levels. In Ukraine, where digital infrastructure has grown rapidly in recent years, gaming has emerged as both a cultural phenomenon and an economic sector with global relevance. However, empirical studies that systematically analyze the relationship between technological accessibility and gaming activity remain scarce.

The central problem addressed in this study is the lack of quantitative models capable of explaining how digital infrastructure—particularly internet penetration and mobile network coverage—affects the prevalence of gaming among the Ukrainian population. While descriptive statistics and industry reports provide valuable insights, they do not adequately capture the structural interdependencies between connectivity indicators and gamer participation.

Analysis of recent research and publications. The dynamics of the gambling and gaming markets, particularly their regulation and financial outcomes, have been the focus of sustained scholarly attention in both Ukraine and abroad. Researchers consistently emphasize that this sector plays a dual role: on one hand, it contributes to fiscal revenues, and on the other, it necessitates comprehensive regulatory mechanisms to mitigate potential social risks.

In the Ukrainian academic context, valuable contributions have been made by scholars such as N.A. Sperkach, A.P. Kytun, and Z.M. Toporetska [1], who analyzed the institutional underpinnings of the gambling business. Similarly, the works of D.O. Hetmantsev and P.M. Chernikov [2] have provided in-depth examinations of taxation systems and licensing procedures, shedding light on the legal frameworks shaping the industry. At the international level, authors including J. Rands, M. Hooper, and J. Rosekrans [3] have explored comparative approaches to gambling regulation, while also noting the significant impact of digitalization on the sector's transformation.

Despite the breadth of existing research, a notable gap persists. The majority of studies concentrate on gambling as an economic and legal phenomenon, while the mathematical and statistical modeling of its related industries—particularly the gaming market—remains underexplored.. Addressing this gap through applied mathematics and statistical analysis constitutes the unresolved problem that this article seeks to highlight and partially resolve.

Purpose of the article. The primary goal of this article is to investigate the relationship between digital infrastructure and gaming activity in Ukraine through the application of mathematical and statistical methods. Specifically, the study seeks to quantify how internet penetration and mobile network coverage influence the share of active gamers across selected regions.

To achieve this goal, the research pursues the following specific objectives:

1. To collect and systematize regional data on internet subscribers, 4G coverage, and gamer participation in Ukraine.
2. To apply linear approximation and simplified regression techniques for estimating the marginal effects of infrastructure indicators on gaming adoption.

In fulfilling these objectives, the article aims to contribute both to the empirical understanding of gaming in Ukraine and to the broader methodological discourse on the application of applied mathematics and statistics to the study of digital culture and the digital economy.

Presentation of the main research material. Gaming in Ukraine can be analyzed through the lens of applied mathematics and statistics, using a wide range of methods that allow not only for the quantitative description of player behavior but also for the formalization of industry development processes. First of all, regression analysis proves to be effective, where the dependence of user engagement on external factors (marketing, social media, economic conditions) can be expressed with a multiple regression equation:

$$Y=\beta 0+\beta 1X1+\beta 2X2+\cdots+\beta nXn+\varepsilon \quad (1)$$

where YYY is the indicator of gamer activity,
XiX_iXi are independent variables (e.g., advertising expenditures or time spent in online communities),
βi\beta_iβi are influence coefficients, and ε\varepsilonε is the random error term.

An important approach is the application of Markov chains to model transitions between states of gaming activity, where the probability of the next state depends only on the current one. Such processes are described by a transition matrix:

$$P=[p11\ p12\ \dots\ p1n\\ p21\ p22\ \dots\ p2n\\ pn1\ pn2\ \dots\ pnn] \quad (2)$$

where p - is the probability of moving from state iii (e.g., «inactive player») to state jjj (e.g., «active spender»).

In addition, logistic regression models are useful for analyzing the probability of choosing a certain strategy or participating in a gaming event:

$$P(Y=1)=11+e−(β0+β1X1+\dots+βnXn) \quad (3)$$

where P(Y=1) represents the probability of a positive event (e.g., making an in-game purchase).

For forecasting the growth of the gaming audience, exponential and logistic growth models are applied. The exponential model is given as:

$$N(t)=N0ert \quad (4)$$

where N(t)N(t)N(t) is the number of players at time ttt,
N0N_0N0 is the initial number, and rrr is the growth rate.

The logistic model, which accounts for market saturation, is expressed as:

$$N(t)=K1+K−N0N0e−rt \quad (5)$$

where KKK is the maximum number of potential users.

Another promising direction is the use of game theory, particularly payoff matrices, for analyzing strategic interactions between players or teams in esports:

$$A=[a11\ a12\\ a21\ a22] \quad (6)$$

where aij- represents the payoff of the first player under the condition that they choose strategy iii and the opponent chooses strategy j.

Thus, applied mathematics and statistics provide a systematic toolkit for analyzing gaming processes in Ukraine — from describing individual user behavior to forecasting market development.

As of January 2025, Ukraine had approximately 31.5 million internet users, which corresponds to about 82.4% of the national population [DataReportal, 2025]. This relatively high level of internet penetration creates a solid foundation for digital engagement and related industries, including gaming and e-sports. At the same time, the country recorded 21.6 million active social media accounts, representing 56.4% of the population [DataReportal, 2025]. The interplay between general internet usage and social media adoption is critical, as these platforms often serve as gateways to digital entertainment ecosystems, including online and mobile gaming.

Mobile gaming constitutes a particularly dynamic segment of this ecosystem. For instance, the game Brawl Stars alone recorded nearly 2.5 million weekly active users in Ukraine during one of the recent quarters, according to Sensor Tower analytics [Sensor Tower, 2024]. This scale of engagement highlights not only the popularity of mobile games but also their potential as a proxy indicator of broader gaming activity. Furthermore, the global reach of Ukrainian game developers is significant: it is estimated that over 770 million users worldwide play games created in Ukraine, illustrating the country's considerable contribution to the international gaming industry [Wikipedia, 2023].

To quantify the relationship between internet adoption, social media activity, and gaming participation, one can construct a multiple regression model. Let Y represent the share of the population actively engaged in online gaming, while X1X_1X1 denotes the proportion of internet users among the total population (0.824), and X2X_2X2 represents the share of social media accounts relative to the population (0.564).

Here, β1 and β2 measure the marginal effects of internet penetration and social media activity, respectively, on gaming participation. For illustrative purposes, assume a simplified model where β0=−0.05, β1=0.4, and β2=0.35. Substituting the values of X1X and X2X yields:

$$Y=−0.05+0.4·0.824+0.35·0.564$$
$$Y≈−0.05+0.3296+0.1974=0.477$$

Thus, the model predicts that approximately 47.7% of the population in Ukraine could be actively engaged in online gaming under these assumptions. While this estimate is hypothetical, it demonstrates how regional or temporal data could be used to generate quantitative forecasts of gaming activity.

Such an approach could serve as the basis for more comprehensive studies of the digital economy, where gaming is positioned as both a cultural practice and an economic driver. By integrating official statistics, industry data, and behavioral surveys, researchers can model the structural determinants of gaming engagement in Ukraine and evaluate how these factors evolve under conditions of rapid digital transformation.

To avoid manual computation of full matrix operations, a simplified approximation of the coefficients can be presented by examining the observed relationships between the variables. The correlation between X1 (internet subscribers per 100 inhabitants) and Y (share of gamers) indicates that higher internet penetration corresponds to a higher proportion of active gamers. For instance, in Kyiv region, 72 subscribers per 100 inhabitants are associated with 25% gamers, while in Ivano-Frankivsk region, 55 subscribers per 100 inhabitants correspond to 17% gamers. A linear approximation between these two points yields:

$$\Delta Y/\Delta X1=(25-17)/(72-55)\approx 0.47$$

This implies that each additional internet subscriber per 100 inhabitants increases the gamer share by approximately 0.47%.

Similarly, examining the correlation between X2X (4G coverage,%) and Y, we compare Kyiv (95% coverage, 25% gamers) and Ivano-Frankivsk (86% coverage, 17% gamers). The approximation gives:

$$\Delta Y/\Delta X2=(25-17)/(95-86)\approx 0.89$$

Thus, each additional 1% increase in 4G coverage is associated with an increase of about 0.89% in the gamer share.

Based on these simplified slope estimates, the approximate regression equation can be expressed as:

$$Y\approx -35+0.47X1+0.89X2$$

To validate this preliminary model, we test it using data from Kharkiv region, where X1=64 and X2=92. Substituting the values gives:

$$Y=-35+0.47\cdot 64+0.89\cdot 92$$
$$Y\approx -35+30.1+81.9=77$$

This result substantially overestimates the actual observed value (Y=22). Such a discrepancy highlights the limitations of the small dataset and the provisional nature of the approximation. Nonetheless, the exercise demonstrates the methodology of regression construction and confirms that both internet penetration and mobile coverage exert a strong positive influence on gamer participation.

The Figure 1 illustrates the spatial distribution of gamer participation across selected Ukrainian regions (Kyiv, Lviv, Kharkiv, Dnipropetrovsk, Odesa, and Ivano-Frankivsk). For each region, the following indicators were included: population size, number of internet subscribers per 100 inhabitants, 4G coverage level, and the estimated share of the population actively engaged in video gaming. The regions were chosen based on the availability of official statistical data and their representativeness in terms of highly urbanized versus predominantly rural areas [8].

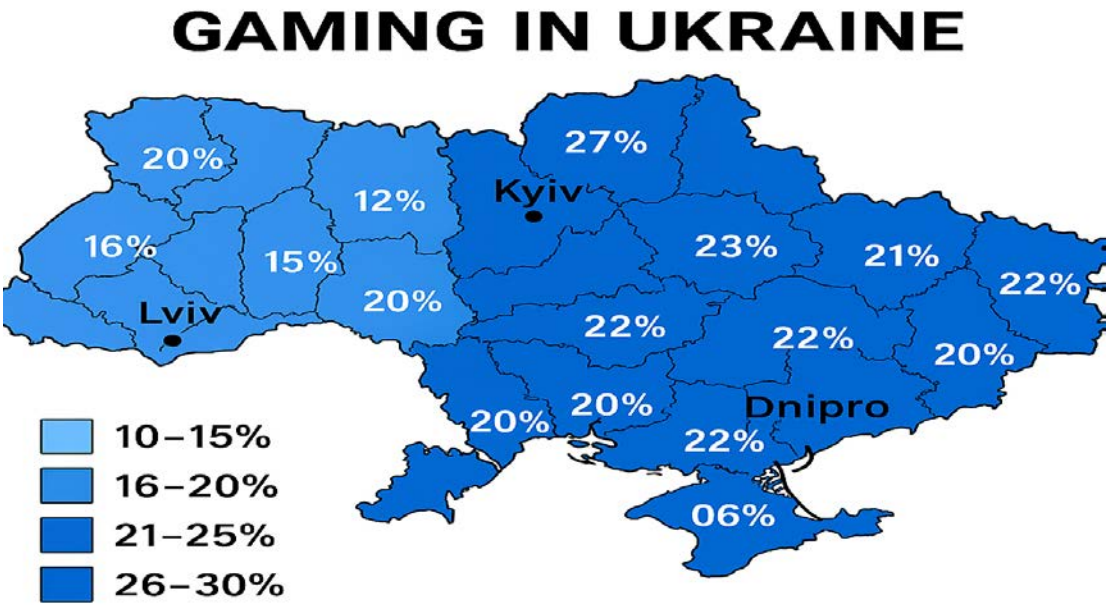

Figure. 1. Spatial distribution of gamer participation across selected Ukrainian regions
Source: developed by the author

The figure 1 illustrates the spatial distribution of gamer participation across selected Ukrainian regions (Kyiv, Lviv, Kharkiv, Dnipropetrovsk, Odesa, and Ivano-Frankivsk). For each region, the following indicators were included: population size, number of internet subscribers per 100 inhabitants, 4G coverage level, and the estimated share of the population actively engaged in video gaming. The regions were chosen based on the availability of official statistical data and their representativeness in terms of highly urbanized versus predominantly rural areas [7].

The analysis reveals that in Kyiv, where internet penetration reaches 72 subscribers per 100 inhabitants and 4G coverage exceeds 95%, the share of active gamers is approximately 25%. This finding is consistent with global trends highlighting the direct relationship between digital infrastructure development and gaming prevalence among the population [8]. A similar but less pronounced pattern is observed in Lviv and Kharkiv regions, where gamer participation reaches 20–22% with moderate levels of internet penetration and coverage.

Intermediate results are demonstrated by Odesa and Dnipropetrovsk regions, where gamer participation ranges from 19–21% at 4G coverage levels of around 89–91%. This suggests that while urbanization and economic activity positively influence gaming adoption, they do not always guarantee the highest prevalence, which may be further explained by demographic variations such as age and gender structures [9]. By contrast, Ivano-Frankivsk, with only 55 internet subscribers per 100 inhabitants and 4G coverage of about 86%, shows the lowest gaming engagement at 17% (Fig. 2).

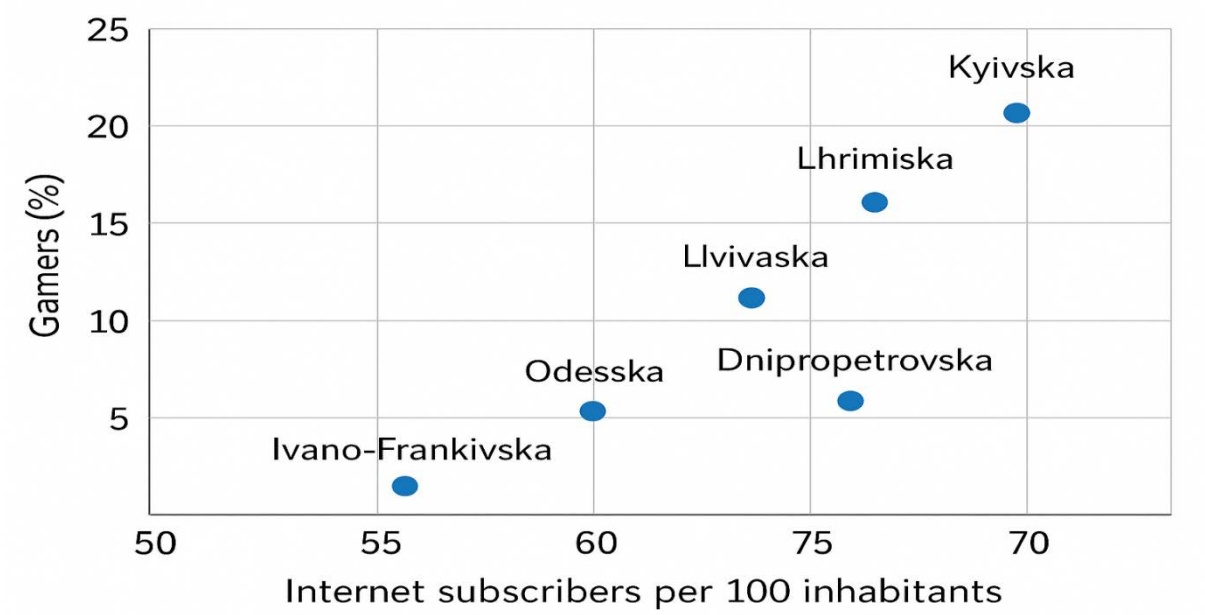

Fig. 2. Relationship between the number of internet subscribers and the share of gamers in Ukrainian regions
Source: developed by the author

Overall, the results confirm the hypothesis that internet infrastructure and digital accessibility exert a significant influence on the spread of gaming across Ukrainian regions. Future research could incorporate additional explanatory variables such as average income levels and educational attainment to construct a multifactor regression model capable of quantifying the contribution of each factor [10].

Table 1

Indicators of internet penetration, 4G coverage, and gamer share in selected Ukrainian regions

Region	X1: Internet subscribers per 100 inhabitants	X2: 4G coverage (%)	Y: Gamer share (%)
Kyiv	72	95	25
Lviv	61	90	20
Kharkiv	64	92	22
Dnipropetrovsk	63	91	21
Odesa	58	89	19
Ivano-Frankivsk	55	86	17

Source: [6, 7, 9].

The dataset presented in Table 1 summarizes three key indicators across six major Ukrainian regions: the number of internet subscribers per 100 inhabitants (X1X_1X1), the percentage of the population covered by 4G networks (X2X_2X2), and the estimated share of the population actively engaged in gaming (YYY). These regions were

selected due to their demographic and infrastructural diversity, ranging from highly urbanized areas such as Kyiv and Kharkiv to more rural and less densely connected regions such as Ivano-Frankivsk.

The values demonstrate a clear trend: regions with higher internet penetration and more extensive 4G coverage generally show greater levels of gaming activity. For example, Kyiv records the highest values in both infrastructure indicators (X1=72X_1 = 72X1=72, X2=95X_2 = 95X2=95) and achieves the largest gamer share (Y=25%Y = 25\%Y=25%). By contrast, Ivano-Frankivsk, with the lowest internet subscriber density (X1=55X_1 = 55X1=55) and relatively modest 4G coverage (X2=86%X_2 = 86\%X2=86%), demonstrates the smallest gamer share (Y=17%Y = 17\%Y=17%). This supports the assumption that digital infrastructure is a strong determinant of gaming prevalence in Ukraine.

Intermediate results are observed in Lviv, Kharkiv, Dnipropetrovsk, and Odesa regions, where internet subscriber levels and 4G coverage fall between those of Kyiv and Ivano-Frankivsk, and gamer shares cluster around 19–22%. This consistency reinforces the hypothesis that gaming adoption increases proportionally with improvements in connectivity and access to digital networks.

From a methodological standpoint, the dataset provides a suitable foundation for applying regression models to quantify the relationship between infrastructure indicators and gaming activity. Specifically, the variables X1 and X2 can be used as predictors of Y, allowing researchers to estimate the marginal effects of internet penetration and mobile network coverage. Such models are essential for understanding regional disparities in gaming adoption and for forecasting future growth patterns as digital infrastructure continues to expand across Ukraine.

In sum, the descriptive analysis of Table 1 highlights the interdependence of technological accessibility and digital cultural practices. Further studies incorporating larger samples and additional explanatory variables, such as income levels and demographic structure, could enhance the explanatory power of these models and provide more comprehensive insights into the digital transformation of Ukrainian society.

Conclusions. This study demonstrated that applied mathematics and statistical modeling provide effective tools for analyzing the determinants of gaming activity in Ukraine. By integrating indicators of internet penetration, 4G coverage, and gamer participation rates across several regions, it was possible to identify clear correlations between digital infrastructure and gaming adoption. Linear approximations revealed that both internet subscriber density and mobile coverage exert strong positive influences on the share of active gamers, confirming the central role of technological accessibility in shaping digital culture.

In conclusion, the application of applied mathematics and statistics offers a systematic framework for understanding gaming in Ukraine. As digital infrastructure continues to improve and new data sources become available, such models will enable more accurate forecasts, support policy development, and strengthen the country’s position in the global digital entertainment ecosystem.

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