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Original Article

Stages of Aerodrome Sustainable Category Evaluation Nash`s Theories of Equilibrium

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Abstract: *This elaboration explores the application of equilibrium theory to assess the sustainable development of an aerodrome near Gevgelija by analysing how supply, demand, and elasticity interact under constant environmental factors, emphasizing the importance of stable equilibria for sustainable infrastructure expansion. It highlights that multiple equilibria can exist for potential locations, with unstable ones risking unsustainable growth, thus underscoring the need for identifying stable, unique locations that support ongoing development and extension of runway categories. By focusing on plausible adjustment processes that ensure convergence of prices and allocations, the study aims to determine optimal site selection through benchmarking, ultimately ensuring that the chosen location facilitates sustainable aerodrome growth aligned with economic stability and development goals.*

Keywords: *Supply, Elasticity, Equilibrium, Benchmarking, Sustainable development, Aerodrome.*

I. INTRODUCTION

The classification of a general aviation aerodrome in the vicinity of Gevgelija should take into account sustainable development from an environmental impact perspective, accessibility, safety, as well as sufficient economic potential and regional integration for long-term sustainability. This requires setting clear criteria based on spatial planning, economic feasibility, and local benefits, or striking the right balance between private sector interests and state regulation in order to promote regional development, tourism, and reconnection. Market factors, including competition and demand management, also contribute to efficiency optimization and reduced costs, along with research methodologies that incorporate qualitative data from secondary sources and analytical approaches for informed choices. On the whole, this integrated approach looks towards guaranteeing the sustainability of the aerodrome – that is to say, its eco-responsibility and socio-economic contribution resting in a wider regional/global aviation setting.

II. AERODROME SUSTAINABLE DEVELOPMENT IN THE VICINITY OF THE CITY GEVGELIJA ACCORDING TO THE THEORY OF EQUILIBRIUM

Three possible locations, L1, L2, and L3 for the aerodrome near Gevgelija were considered so as to avoid proximity to settlements, be buildable, and the land to be at disposal. This site evaluation will enable the location of the best (most accessible, favorable construction conditions, available land) site for strategically and effectively developing the aerodrome.

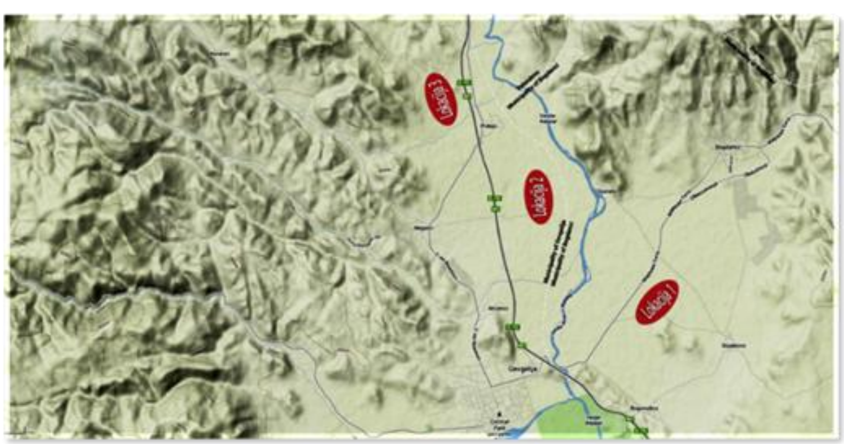


Fig. 1: Topographic features of possible locations

A) *Display of Prices and Markets*

The text emphasizes some basic principles of a market economy, showing how supply and demand determine prices and resources--Adam Smith's "invisible hand" shows that private interests can benefit society if markets are competitive. It illustrates the importance of specialization and the division of labour in promoting productivity gains and greater living standards underpinned by investments such as airfields that not only promote technological innovation but also export competition. Citing market failures like income inequality and ecological damage, the dialogue proposes that both markets and government, rather than either alone, should ensure efficiency, fairness, and societal well-being in a humane society.

B) *Figures*

The basic model of supply and demand represents the foundation of the microeconomy and allows us to understand why and how prices change and what is happening in the market to determine how to develop an aerodrome by the concept of sustainable development. The supply and demand model connects two important concepts: the supply curve and the demand curve, where the supply curve shows the number of flights sold by manufacturers at a given price, with unchanged factors shown in the graph with the *"S"* curve. The vertical axis of the graph shows the price of good "P" for a given quantity offered. The horizontal axis shows the total amount of *"Q"*, for a given time. The supply curve between quantity and price is represented by the equation,

$$Q_s = Q_s(p) \tag{01}$$

The demand curve is the number of goods to be bought at a certain price, and the ratio between the quantity demanded and the price can be written in the form of the equation:

$$Q_d = Q_d(p) \tag{02}$$

A downward-sloping demand curve, such as D, means that at lower prices, the consumer is more willing to purchase in larger quantities) with the result that goods are made available and markets can be taken out of equilibrium if supply and demand are not aligned. At a point where price (Po) and volume (Qo) intersect, supply equals demand, and the market is in equilibrium; more than enough leads to falling prices, and shortages cause prices to rise. Over time, both supply and demand curves shift due to changing market conditions, influencing prices and quantities, and driving the market toward a new equilibrium as these dynamics evolve.

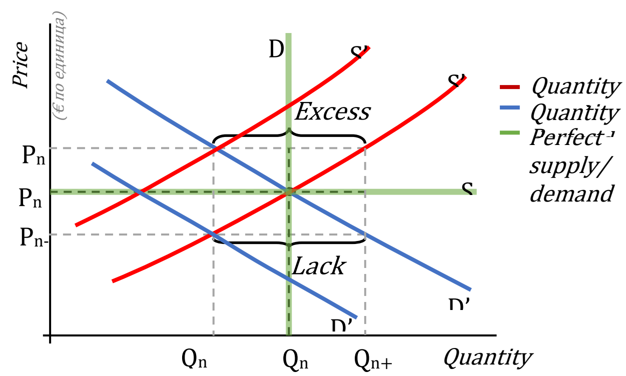


Fig. 2: Supply and Demand Curve, Equilibrium System

The Elasticity measures the sensitivity of one variable to another, a number that tells how many percentages one variable will change if the other increases by a quantity Q and a value of P. This expression can be written as *E_p=(%ΔQ) / (%ΔP)* and means that percentage change *%ΔQ*, means percentage change *Q* a *%ΔP*, means percentage change P^{\prime\prime}. The percentage change of the variable is the absolute value of the change divided by the original level of that variable, where the elasticity of demand is represented as

$$E_p = \frac{\Delta Q/Q}{\Delta P/P} = \frac{P}{Q}\frac{\Delta Q}{\Delta P} \tag{03}$$

Price elasticity of demand has a negative value when the price increases and the amount of demand decreases, hence $\Delta Q/\Delta P$ is negative, as well as Ep, which contributes to the increase of the aerodrome category. When the price elasticity of demand assumes a value greater than *1 {(E}_p>\ 1),* the decrease in the amount of demand and the percentage is greater than the percentage increase in prices. If the price elasticity of demand is less than 1, we say that demand is inelastic. Price elasticity of demand measures how sensitive consumers are to price changes, with high elasticity when substitutes are available, leading to significant demand reductions with price increases, and low elasticity for essential or substitute-scarce goods, especially in the short term. It is calculated as the percentage change in quantity demanded divided by the percentage change in price, and factors such as time horizon and availability of substitutes influence its magnitude. Conversely, price elasticity of supply indicates how responsive producers are to price changes, calculated similarly, reflecting the degree to which quantity supplied varies with price fluctuations.

C) Sustainable Aerodrome Development

Sustainable development seeks to achieve a balance between economic, social, and environmental dimensions—acknowledging that the three goals are closely linked: Economic growth can generate wealth but must be pursued in ways that do not result in negative impacts including the destruction of natural resources as well as poverty and inequality (social), guaranteeing a healthy planet for current and future generations along with highly fulfilling lives within it.

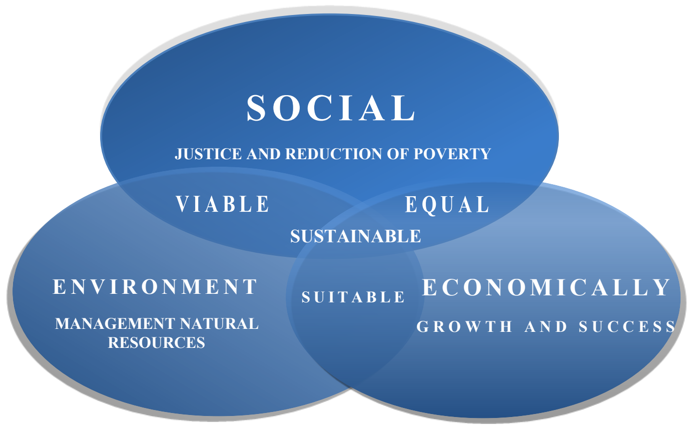


Fig. 3: Environmental goals acceptable for sustainable development

The sustainable development airport policy for the Gevgelija region supports a composite of economic growth alongside social inclusion and environmental preservation, based on the IUCN, UNEP, and WWF levels. It focuses on stakeholder participation, institutional change, capacity building, and financial modalities designed to facilitate long-term economic development with minimal ecological impacts through mechanisms in strategic planning, pollution control management, and renewable energy introduction. The policy places a high emphasis on transparency, inclusivity, and intergenerational equity with an aim to improve social cohesion, environmental health, and economic resilience while not destroying the environment or harming communities through informed site selection. This integrative approach is one that promotes sustainable development so as to boost regional growth, reduce environmental impact, and is based on the premise of a coupling between infrastructure expansion and ecological-social sustainability.

III. GAME THEORY

Economic stability is crucial to bring unity back in an interdependent economy by maintaining a balance between qualitative and quantitative GDP components for the surety of social reproduction. Phenomenological and probabilistic models examine macro aggregates to evaluate the stability of a system, typically by means of mathematical frameworks, whereas general equilibrium models formalize interactions under the rationality hypothesis, along with market-clearing, favouring sustainability. Game theory expands further by studying strategic rationalization of actors in order to reach stable solutions (such as Nash equilibria). Eventually, suppressing demand by pricing and rationing supply makes markets function well, prevents excesses, and supports an efficient and robust economy.

A) Nash Equilibrium

A strategic profile is a set of strategies, one for each player, where the strategic profile is a Nash equilibrium, if and only if no player can do better in a case when they unilaterally change their strategies in the game. This means that if the question is: “Knowing the strategy of other players, is it possible to make money by changing your strategy?”, and if any player reacts positively, then it is not a Nash equilibrium. If each player prefers not to switch, then the strategic profile is a Nash Equilibrium where each Nash Equilibrium strategy is the best response to the other players' strategies.

Formally, let S_i be a set of all possible strategies for player i, where $i=1,\ \dots\ N$. *Let* $s^\ast=(s_I^\ast,s_{-i}^\ast)$ be a strategic profile, a set consisting of one strategy for each player, where $s_{-i}^\ast$ denotes N-1, the strategy of all players other than i. *Let* $u_i=(s_i,s_{-i}^\ast)\$ be the payout of player I as a function of strategies. The strategic profile $s^\ast$ is a Nash Equilibrium if

$$u_i(S_i^*, S_{-i}^*) \geq u_i(s_i, s_{-i}^*) foralls_i \epsilon S_i \quad 04$$

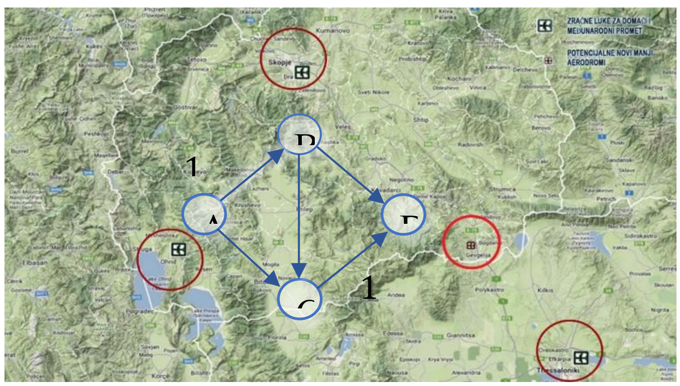
The strategic set S_i can be different for players, and its elements can be different for mathematical objects where the player chooses between strategies, and $S\_i=\{Yes,\backslash\ No\}$. A set of strategies can be a final set of conditional strategies, in other words, $S\_i=\{Yes|p\backslash =Low,\backslash\ No|p\backslash =High\}$, which can be an infinite set of $S\_i=\{price\}$. as Price is a positive real number. Nash Evidence assumes a final strategic set of requirements that sometimes seems irrational from a third-party perspective because Nash Balance is not necessarily Pareto. There can be irrational consequences in sequential games because players "threaten" each other with threats they would not make, which can be important as a tool for analysis.

B) Nash`s Existence Theorem

Nash has proven that if mixed strategies are allowed, playing with a finite number of players where one chooses between finally very clean strategies has one Nash equilibrium, as a pure strategy for each player by distributing the probability among strategies for each player equally. Nash equilibrium does not exist if the set of choices is infinite and unbounded, and exists if the set of choices is compact with constant payouts in each player's strategies. When two players name a number at the same time, then the winner is the one who names the higher number, or if each of the two players chooses a real number strictly less than 5, the winner is the largest number.

C) Network Traffic

In the network graph, the values of the edges are the travel time of the x planes traveling along that edge. The Nash equilibrium determines the expected traffic flow in the network, and the graph shows that there are x "planes" traveling from A to D.



A – Aerodrom in Ohrid, B – Aerodrom in SKopje, C – Aerodrom in Solun, D – Aerodrom in Gevgelija

Fig. 4: Locations of the existing aerodromes within the airspace

The situation is modeled as a "game" where each player has 3 strategies, where each strategy is a path from A to D (one of ABD, ABCD, or ACD), the "payback" of each strategy is the travel time of each route where the aircraft travels through ABD exceeds the travel time of $(1 + x / 100) +2$, and x is the number of aircraft per edge AB. The payoff for any given strategy depends on the choice of other players, and the goal is to minimize travel time. Equilibrium occurs when the time on all tracks is the same, and where no pilot has an incentive to change lanes, as this increases travel time. If out of 100 aircraft travel from A to D, and each passenger now has a total travel time of 3.25, this leads to the conclusion that this distribution is optimal. When 25 aircraft choose the ABD route, the flight length will be $1 + 0.25 + 2 = 3.25$, 50 aircraft on the ABCD route will fly $1 + 0.5 + 0.25 + 1 + 0.5 = 3.25$ and on the ACD route 25 aircraft will fly $2 + 1 + 0.25 = 3.25$ then it would be an equilibrium by another possible way reducing the efficiency of a system known as the Braess paradox.

IV. BENCHMARKING COSTS OF KEY-VALUE CHAIN ACTIVITIES

Benchmarking in aerodromes serves as a strategic tool for continuous improvement, enabling comparison of costs, efficiency, and practices to identify best practices and areas for enhancement, ultimately fostering a competitive edge both locally and internationally. Its objectives include improving the organization, making their operation more efficient, and implementing new modern technologies, etc, as a contribution to the enhancement of performance and competitiveness with broader regional development in Gevgelija. Given the challenges of getting it right in terms of data due to sensitivities and different operating platforms, benchmarking institutionalises a culture of learning, adaptation, and proactive improvement that resonates well with some basic principles found in self-interest leading to collective good (individual ambition for common good) and converting knowledge into actionable plans/programmes geared towards securing sustained success.

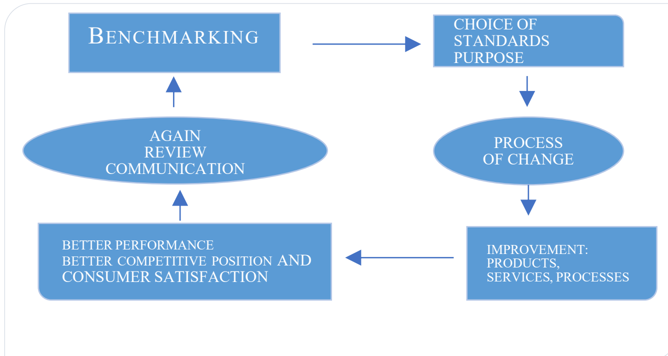


Fig. 5: Activities and goals of benchmarking

Benchmarking is conducted in four main stages, from the definition and understanding of the problem until the implementation or application of the solution (see Figure 3).

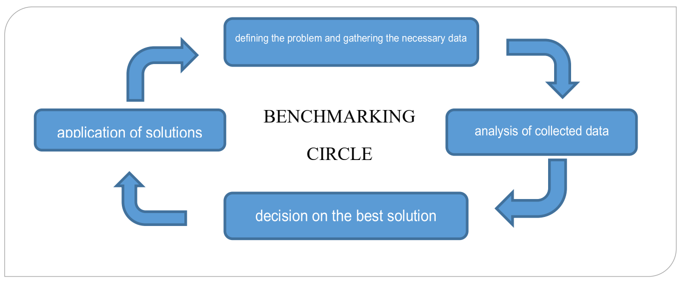


Fig. 6: Benchmarking circle

The process itself can be divided into several stages: the first one includes an analysis of the data collection system and team members, the search for efficient partners for data provision; the second involves bringing the procedures into line with benchmarks from a theoretical point of view, and further consolidation (comparison) of deviations in order to find their causes. This methodical methodology is to always seek improvement, and by comparing their practice against industry benchmarks, organizations can further develop models that they need in order to improve efficiency, security, and competition. The result is the implementation of change, coupled with ongoing review and modification to deliver continuous growth and excellence in the organization.

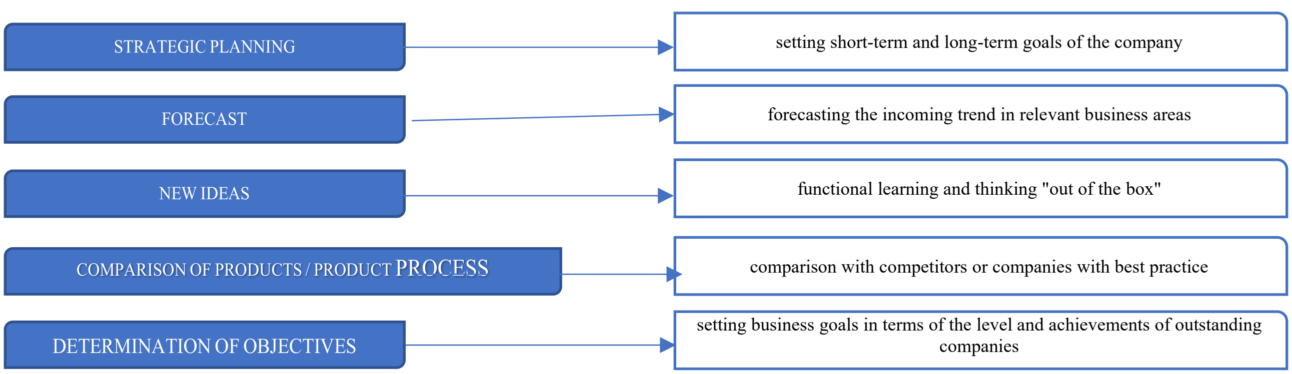


Fig. 7: Scope of Benchmarking

A) *Strategic Options for Cost Correction*

Benchmarking is an essential instrument for the introduction of competitiveness into its companies through examination of in-house and external forces, determination of development objectives, and supervising change. For an aerodrome, it aids in progressive upgradation of function, Implementation of five key areas that match global standards, and learning from the world's best practices. Assessing itself through competition from the global horizon, Benchmarking enhances identifying Strengths, weaknesses, and maintaining agility in the air, at least, it serves as a cornerstone for continuous growth and operational excellence within the aviation industry.

B) Game theory representation of the location selection for sustainable development

The Category Development Index (CDI) can be modeled in game theory frameworks by considering the strategic interactions among investors, supply, demand, and benchmarking influences, capturing how decisions in locations L_1, L_2, and L_3 affect project outcomes. A representative equation might be formulated as CDI = (*Σ_i* (*Market Share_i* / *Market Potential_i*) * *Weight_i*) * *Profitability Factor*, where Market *Share_i* and Market *Potential_i* reflect demand-supply dynamics, and *Weight_i* captures the strategic importance or competitive positioning of each location. This formulation enables decision-makers to optimize timing and strategies by analyzing how individual location-specific factors and their interdependencies influence overall category knowledge and profit maximization, aligning with game-theoretic principles of strategic decision-making under competition.

$$CDI = (\text{Percentage of total product category: Percentage of total estimation of a project}) * 100$$

The overall assessment of Gevgelija aerodrome at location L3 confirms it to be a strategic location which is acceptable with regard to geomorphological, meteorological, infrastructure, and strategically assessed parameter values, which further corroborates the game theory analysis by demonstrating its stability and increasing benefit potency. This multi-pronged approach shows that what L3 brings to it is not only short-term operational (again excluding more sensible development in and around L3), but also lines up with regional objectives for growth and sustainability, which includes the successful rollout of a sports school infrastructure, making it a smart long-term investment, befitting its progressive nature.

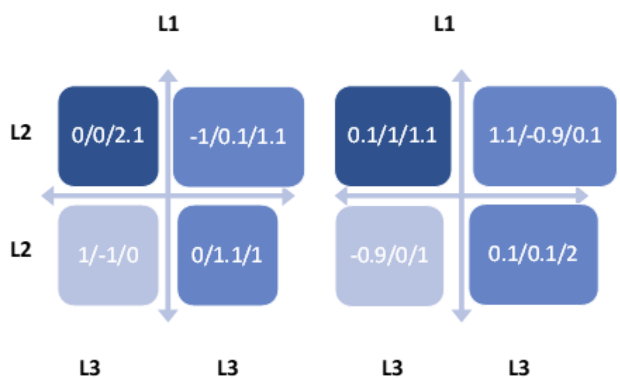


Fig. 8: Game theory matrices for location selection

V. CONCLUSION

Such an equilibrium system about sustainable aerodrome operation opens up a new area, which is in game theory, especially the Nash Equilibrium, to achieve rational resource allocation and supply-demand balance for Category A1 aerodromes within the framework of holding the goal for sustainable development. Through benchmarking and the use of results in multivariable calculus, participants can seek alternative solutions in the presence of multiple potential ones and select the most stable and most beneficial solution among all solutions so that no participant is fostered by deviation. And this is exactly the long-term approach that helps sustain by acknowledging resource constraints, environmental impacts, and operational efficiency, and supports strategic decision making on economically efficient/ecologically sustainable investments.

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VI. REFERENCES

[1] Načela ekonomije i ekonomije, Ratko Zelenika, 2008.
[2] Metodologija i tehnologija izrade znanstvenog i stručnog rada, Ratko Zelenika, Kastav, 2015
[3] Strateški menadžment, Arthur A. Thompson, Jr.,A.J.Strickland III, John E. Gamble, MATE 2008
[4] Ekonomija, 19 izdanje, Paul A. Samuelson, William D. Nordhaus MATE 2011
[5] Mikroekonomija, peto izdanje, Robert S. Pindyck, Daniel L. Rubinfeld MATE 2005
[6] Aerodromes, Annex 14 to the Convention on International Civil Aviation, Volume I, Aerodrome Design and Operations, International Civil Aviation Organization, Fifth Edition, 2009
[7] Stolport Manual, Doc. 9150- AN/899, International Civil Aviation Organization, Second Edition, 1991
[8] Classical and neoclassical theories of general equilibrium, Vivian Walsh, Harvey Gram, Oxford University press, 1980, page 245/268
[9] Dynamic General Equilibrium Modeling, Burkhard Heer, Alfred Maussner, Springer, 2nd edition, 2009
[10] Koncepti ravnoteže u ekonomskoj analizi, Jasminka Šohinger, Narodne novine, Zagreb, 1991
[11] The journal of Economic Perspectives, Summer 2010

[12] Renko, N., Delić, S., Škrtić, M. (1999.) Benchmarking, Mate d.o.o., Zagreb, str.14.
[13] Osmanagić Bedenik, N. i Ivezić, V. (2006), Benchmarking kao instrument suvremenog kontrolinga, Zbornik Ekonomskog fakulteta u Zagrebu, 4(65): 337.
[14] Štoković, I. (2004), Benchmarking u turizmu, Економски преглед, 55(1-2): 69.
[15] Aerodromes, Annex 14 to the Convention on International Civil Aviation, Volume I, Aerodrome Design and Operations, International Civil Aviation Organization, Fifth Edition, 2009
[16] Stolport Manual, Doc. 9150- AN/899, International Civil Aviation Organization, Second Edition, 1991
[17] Carr, D.: City Airports still at centre of controversy, Jane`s Airport Review, September 1995
[18] Benchmarking and tourism, Economic Review, Oktoković, I. (2004), 55 (1-2): 69.
[19] Osmanagić Bedenik, N. and Ivezić, V. (2006), Benchmarking as an instrument of modern controlling, Proceedings of the Faculty of Economics in Zagreb, 4 (65): 337.
[20] Renko, N., Delić, S., rtkrtić, M. (1999.) Benchmarking, Mate d.o.o., Zagreb, p.14.
[21] [Online]. Available: https://en.wikipedia.org/wiki/Sustainable_development
[22] [Online]. Available:https://en.wikipedia.org/wiki/Nash_equilibrium
[23] [Online]. Available:https://opentextbc.ca/principlesofeconomics/chapter/3-1-demand-supply-and-equilibrium-in-markets-for-goods-and-services/
[24] [Online]. Available:http://study.com/academy/lesson/what-is-benchmarking-definition-types-process-examples.html
[25] [Online]. Available:http://www.zakshow.com/the-5-phases-of-benchmarking/
[26] [Online]. Available:http://www.mzoip.hr/doc/Strateska/LNG_POGLAVLJE_4.pdf
[27] [Online]. Available:http://www.mnavigation.mk/Data/Sites/1/media/eaip/pdf/gen/LW_GEN_1_1_EN.pdf
[28] [Online]. Available:https://www.maa.org/sites/default/files/pdf/ebooks/GTE_sample.pdf