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TRANSPORT ECONOMIC WITH THEORY OF EQUILIBRIUM REPRESENTATION FOR AERODROME CONSTRUCTION

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ABSTRACT

The discussion emphasizes that achieving sustainable airport development hinges on understanding complex economic equilibria, where strategic decision-making, as modeled by game theory, plays a vital role in balancing supply and demand, pricing strategies, and competitive behaviors among airports. The concept of general equilibrium illustrates the interconnectedness of resource allocation, prices, and consumer preferences, ensuring that production and consumption are harmonized without excess demand or supply. Strategic interactions, whether cooperative or non-cooperative, influence how airports set prices and respond to competitors, with Nash equilibria providing stable outcomes that maximize profits while maintaining market stability. Ultimately, effective management involves analyzing resource constraints, price ratios, and consumer behaviors to facilitate optimal resource distribution and service provision in a sustainable and balanced manner.

1.0 INTRODUCTION - SIMULTANEOUS SUPPLY AND DEMAND MODELS

So far, the discussion has focused on models in which supply characteristics are implicitly exogenous and fixed, and hence models that are specified in single equations. This constraint can be relaxed if it is believed that one or more of the supply variables are not actually exogenous, but rather dependent on the endogenous variable representing traffic volume. In such a case, a multi-equation model would be necessary to properly estimate the parameters of the demand model. Simultaneity between demand and supply has so far been assumed in the estimation of traffic demand models, especially in urban transport. This is justified on the grounds that supply models can be estimated independently of engineering-type analyses, and that for each demand model, the values of the supply variables given at each traffic level are fixed and exogenous, having been previously estimated. This assumption is relaxed in some of the route choice models where the balance between demand and supply is directly sought. The use of time series analysis in air travel demand modeling opens up the issue of simultaneity, as observed traffic trends and supply variables such as price and capacity often cannot be assumed to be independent. This bidirectional causality can result in model systems that are quite difficult to calibrate. One of these difficulties arises from what is called the identification problem in econometrics.[1]

1.1 The Problem of Identification

[1] The demand for air transportation, chapter 9, strana 270

This problem occurs when a model system (more than one equation) contains bidirectional causality such that there is some kind of imbalance between endogenous and exogenous variables. Since exogenous variables are the source of information on which the estimation of model parameters is based, an insufficient number of them can make it impossible to estimate the parameters of all endogenous variables. Equations that do not contain a sufficient number of exogenous variables and whose parameters cannot be estimated are called unidentified equations. The identification problem can be illustrated with a simple example.

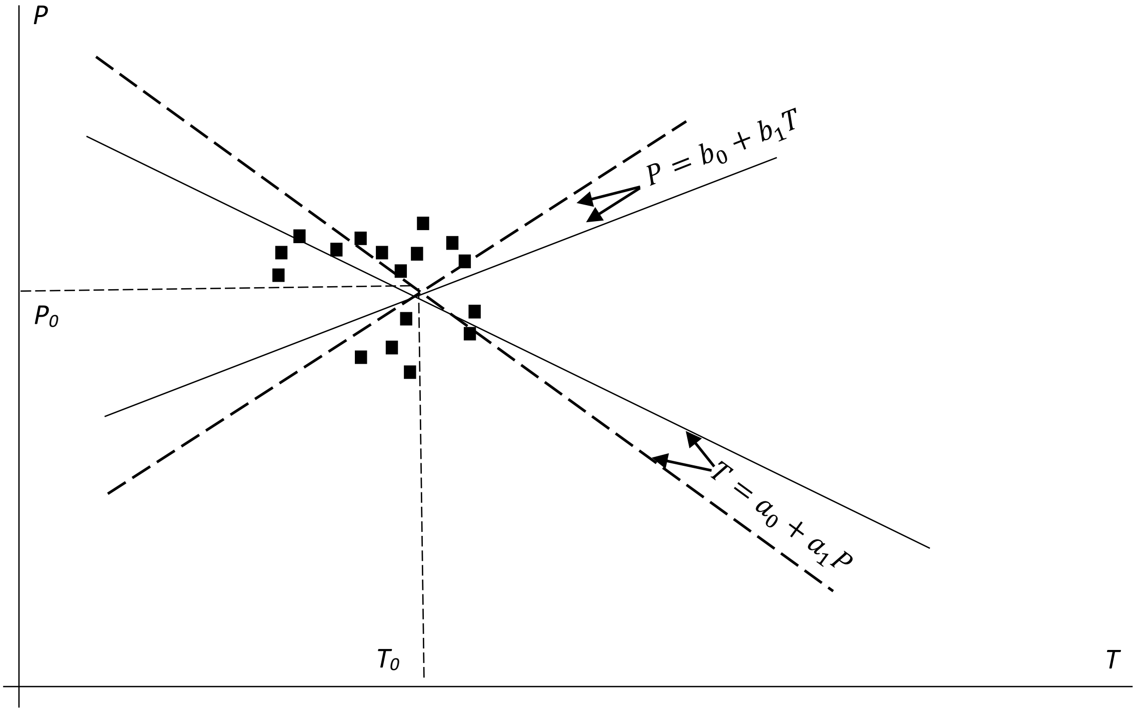

Figure 1, Unidentified Demand and Supply Functions[2]

Assume that the demand and supply model system is given by

$$T = a_0 + a_1 P$$
$$P = b_0 + b_1 T$$

where T is the traffic volume; P is the unit price; and a0, a1, b0 and b1 are parameters to be estimated from observation. The two equations of this model are said to be unidentified because it is not possible to estimate their parameter value from empirical observations. Referring to fig. 9.5, it can be seen that the two equations will result in equilibrium, if at all, at only one point (Te, Pe). Hence, the observations of traffic volume and price cannot be used to estimate the parameters of any equation, since they will all relate to only one point on each curve. The observations thus obtained will result in an average of the location of the equilibrium point, and a rather poor average at that, as indicated by the possible scatter in the data illustrated in

[2] Ауторска слика, Ibidem, strana 271

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Figs. 9.5. To estimate the demand equation or the supply equation, it is necessary for this model to identify an additional exogenous variable. As illustrated in

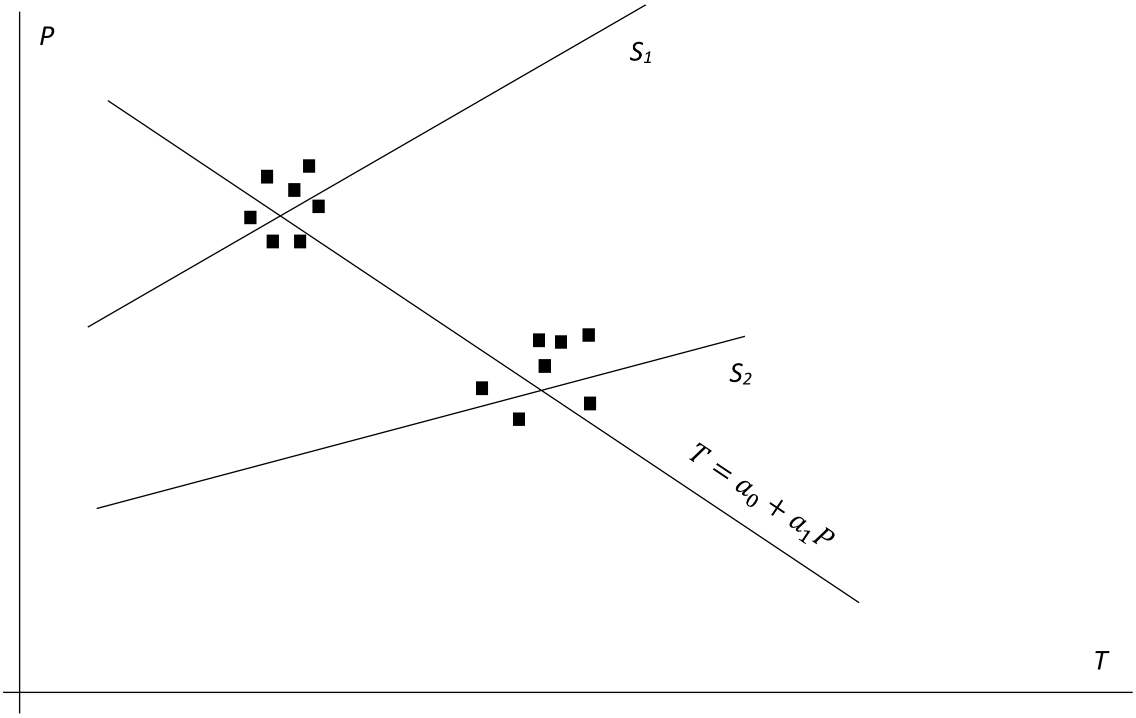

Figure 2, The additional supply variable S allows estimation of the demand function[3]

6) an additional exogenous variable, say S, affects the location of the supply function but not the demand function, which will allow observations of traffic and price at different levels of S. These observations made on different supply curves will allow demand curve estimation. This is analogous to adding an anexogenous variable to the model that will change the in

$$T = a_0 + a_1 P + a_2 S$$
$$P = a_0 + b_1 T + b_2 S$$
$$S = S$$

When S does not affect demand, i.e., when a2=0, it becomes possible to make observations of T and P at different values of S, which means observing the equilibrium points on different supplz curves, but on the same curve on demand. Such observations will allow identification of the demand function, as illustrated in fig. 9.6. Similarly, to estimate the supply function, it would be necessary to have an additional exogenous variable, say Q, that affects income without affecting supply. The model then becomes

$$T = a_0 + a_1 P + a_2 S + a_3 Q$$
$$P = b_0 + b_1 P + b_2 S + b_3 Q$$

[3] Ауторска слика, Ibidem, strana 272

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with both a2=0 and with b3 =0. It is now possible to obtain observations of the equilibrium point at different values of Q, meaning at different levels of demand but with the same supply (without changing S). This will allow estimation of the supply equation, as illustrated in сл. 9.7.

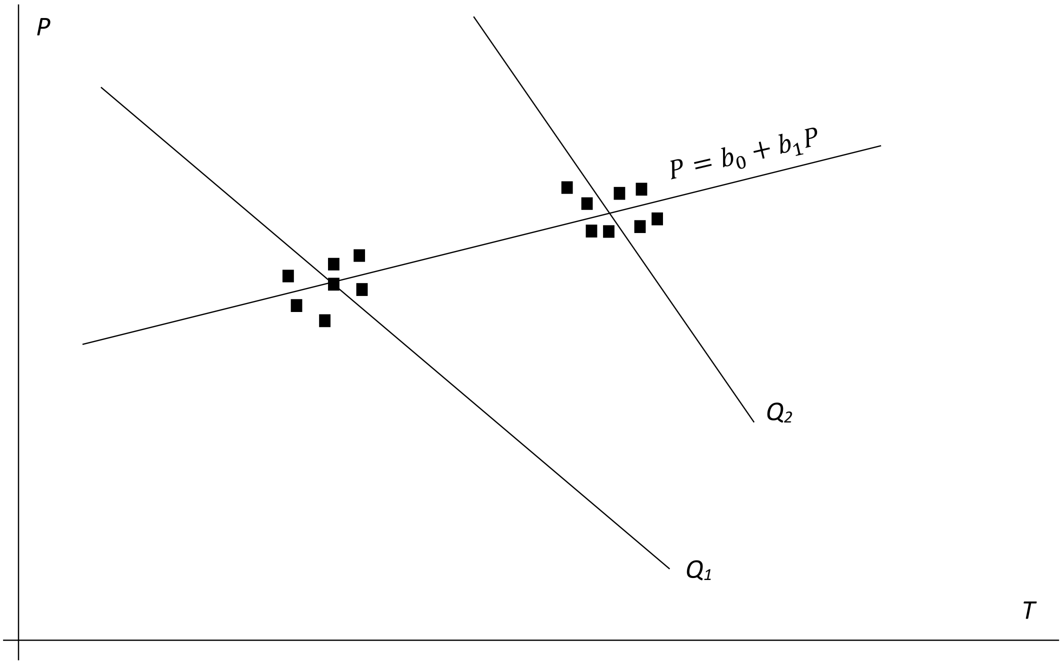

Figure 3, An additional demand variable Q allows estimation of the supply function[4]

This example illustrates the fact that in order for an equation to be identifiable, it is necessary that there be some relationship between the endogenous and exogenous variables involved in it. In general, it is sufficient for the parameter vector for the model equations to be independent and orthogonal. In practice, it is often sufficient to satisfy the following relationship between the number of variables in the equation>Let EX be the number of exogenous variables in the entire model, EN be the number of endogenous variables in the entire model, ex be the number of exogenous variables left in any equation of the model, and let en be the number of endogenous variables left in any equation; then for any model equation to be identifiable, the following relation must hold:

$$(EX - ex) + (EN - en) \geq EN - 1$$

When the equality is strict, then the equation is said to be identified, and when the inequality holds, then the equation is said to be overidentified. An unidentified equation is one for which the inequality in the equation is reserved. It is possible to estimate parameters for identified and overidentified equations, but not for equations that are unidentified. In the example used earlier in this section, the following connections apply. For the equation $T = a_0 + a_1P$ и $P = b_0 + b_1P$, $EX = 0, , ex = 0,\ \ EN = 2, en = 2$, for both equations. Applying the equation in

$$(EX - ex) + (EN - en) \geq EN - 1$$

[4] Авторска слика, Ibidem, strana 273

Follows that

$$(0-0)+(2-2)<(2-1)$$

which is the same for both equations and which shows that neither is identifiable.

For the equation

$$T = a_0 + a_1P + a_2S + a_3Q$$

и

$$P = b_0 + b_1P + b_2S + b_3Q$$

$EX = 2,\ ex = 1,\ EN = 2,\ en = 2,$ for both equations. Again, by applying in $(EX - ex) + (EN - en) \geq EN - 1$, is obtained $(2-1)+(2-2) \geq 2-1$ indicating that the two equations are identified[5].

1.2 Estimates of Simultaneous Equations

Ordinary least squares is not an appropriate technique for parameter estimation of multi-equation model systems. This usually results in biased parameter estimates. For each situation, other regression analysis techniques have been developed, including indirect least squares and two-stage least squares. The former is used only when the model equations are exactly identified, but the latter can be applied to identified and overidentified equations. In order to illustrate the two-stage technique, consider the following model system:

$$T = a_0 + a_1P + a_3Q \qquad P = b_0 + b_1T + b_2S$$

Both equations can be reduced to forms where each involves only one endogenous variable. This can be done by combining the two to get

$$T = a_0' + a_2'S + a_3'Q$$
$$P = b_0' + b_2'S + b_3'Q$$

It is easy to see that, for example,

$$a_0' = \frac{a_0}{(1-a_1b_1)} \quad and \quad a_2' = \frac{a_2}{(1-a_1b_1)}$$

and so on $T = a_0 + a_1P + a_3Q$

$P = b_0 + b_1T + b_2S$ are stated as the reduced form of the structural equations

$$T = a_0' + a_2'S + a_3'Q$$

$$P = b_0' + b_2'S + b_3'Q.$$

Two-stage least squares consists of using the reduced forms to estimate T and P and then re-estimating the structural model as two independent equations

[5] Ibidem, strana 271- 274

$$T = a_0 + a_1 P + a_3 Q \qquad P = b_0 + b_1 T + b_2 S$$

Note that these two equations are no longer simultaneous because P and T are not the same as P and T but are exogenous variables already known during the second stage.

An example of the simultaneous model is the following two-equation model estimated by Eriksen using two-stage least squares:

$$T_1' = -6.35 - 0.52F_t' + 2.00SE_t' - 0.0179LS_t'$$
$$LS_1' = -3.02 + 0.345F_t' - 0.038MP_t' + 0.105T_t'$$

This model was calibrated using data from 1973 and 1974 for a sample of 14 city pairs in the United States. T is the traffic, F is the fare level, SE is the product of the population of the two regions, LS is the level of service variable represented by the ratio of the aircraft's nonstop flight time to the average actual travel time, and COMP is the variable describing market competition which is calculated by summing the squares of the market shares of the airlines serving the market. The model was calibrated using data from 1973 and 1974 for a sample of 14 pairs of regions.

Note that model specification for simultaneous demand and supply is not always necessary. In the case of cross-sectional analysis, it can be assumed that a static equilibrium exists and that supply variables are not influenced by demand. This is not such a good assumption in time series modeling where the data will reflect adjustments in supply conditions from time period to time period that are likely to be influenced by demand. In the specification of time series models with time-lagged effects, such as the partial adjustment model, it is possible to avoid simultaneous estimation of the equations by using the proxy variable method. In this method, the supply variable in the demand equation can be lagged or vice versa. In estimating any of these models, the lagged variable becomes an exogenous variable, already known from the previous time period. This will avoid the need to estimate both models simultaneously. This specification is often necessary when data limitations preclude the application of two-stage least squares or other simultaneous estimation techniques.[6]

2.0 MAIN BODY- GENERAL EQUILIBRIUM - BALANCE OF SUPPLY AND DEMAND

The two-factor commodity parameters of neoclassical allocation theory are consumer preferences and factor ownership to provide the data needed for the role of demand in determining general equilibrium prices and quantities. This solution has one essential feature, which is the unsatisfied demand for production and consumption for input services of factors or for outputs of goods.

The absence of excess demand defines the equilibrium in all neoclassical models, in the analysis of supply correspondence, by requiring that the relative price does not exceed opportunity costs in order to ensure zero excess demand for the factor's services, and if prices exceed opportunity costs, there was excess demand for at least one factor. Price constraints characterize the absence of excess demand for factors by excluding the situation in which the

[6] Ibidem, strana 274- 275

producing agents receive a profit. It is symbolic of situations in which by limiting the price to be less than or equal to the cost of the unit factor without implying equality between supply and demand. The excess supply of any given factor requires a zero price for its services on the grounds that before the allocation problem is solved, it is not known which factor will be scarce, ie. which will have a positive value. All resources in the neoclassical allocation model are in fixed supply, but this does not mean that an additional or marginal unit of any given factor will necessarily add to the value of production. Equilibrium analysis of supply and demand requires the specification of the behavior of resource owners as consumers in a budget set concept that defines alternative consumption bundles for each owner that depend on the individual factors and prices for inputs and outputs to determine the particular choices made. . Aggregate demand depends on consumer tastes, factor prices, and the given allocation of resources among consumers where the general equilibrium for factors requires them to be such that aggregate demand does not exceed its aggregate supply. Supply depends on the condition that relative price ratios do not exceed the corresponding opportunity cost ratios, which leads to the fact that the equilibrium allocation of resources depends on the simultaneous solution of a whole set of relations: resource constraints, price constraints, and equilibrium conditions in supply and demand[7].

The main concept of game equilibrium comes from the work of John Nash, known as the Nash equilibrium. Let us imagine a strategy profile with the property that no individual can do better by choosing an alternative strategy, assuming that all other players choose the strategy described in the strategy profile with simultaneous application to all players called a Nash equilibrium with an illustration of the concept of this example[8].

Game theory is a useful way to capture the mutual actions between individuals when each action has an effect on public funds and monetary services with an emphasis on concepts in the study of development.[9]

2.1 Games, external features and politics

Observing that the two games the prison dilemma and the coordination game represent the kinds of situations of significant interest that reappear in various forms in economic life and certainly in matters of development are exposed to externalities: what one does in the game affects the payoff of the other player and this can jeopardize the possibility of achieving a mutually satisfactory result. If neither player has an effect on the other, we can see them as two isolated units and each can happily go about his or her work without outside interference realizing that the external features are what make the game. As games represented by a prison dilemma and a coordination game with different characteristics where the player wants to make a mistake even though his partner wants to cooperate, it entails a situation where cooperation is a difficulty to maintain as an equilibrium and the player will cooperate if his partner wants to cooperate in a way that entails two equilibria. These games are fundamentally different and

[7] Classical and neoclassical theories of general equilibrium, Vivan Walsh, Harvey Gram, New York, Oxford University, press 1980, strana 245- 246

[8] Развојна економија, Дебраџ Реј, Арц Ламина- 2014, страна 750

[9] Ibidem, strana 757

the economic situations corresponding to one type or the other are treated very differently in relation to the political conditions in reality.

In a prison's dilemma situation, politics must be persistent, constantly controlling and balancing the incentives of individuals to separate themselves from cooperative outcomes. In cases of pollution, a system of output taxes can mimic the social costs that the polluter imposes on others and reduce output to more cooperative levels. In such situations, the tax system must be maintained, otherwise after its removal, the polluters will return to the old ways.

Otherwise, the policies associated with the coordination game may be permanent, given that the only short-term incentives are for elimination from the bad equilibrium. Such incentives can provide situations where a large number of individuals are locked into an unwanted equilibrium that in reality requires a huge coordination move. Such coordination is achieved by setting standards, using certain technologies and computer systems to change the group to the desired equilibrium with penalties or punishments imposed on individuals as a result of the actions of the undesirable equilibrium. The main point derives from the finding that once a new balance is imposed, the penalties or requirements of the standards can be removed without being unnecessarily returned to their old ways[10].

2.2 Time games

In sequencing situations, where the agents in the game move simultaneously, each player makes his move in ignorance of what the other player is doing, however, when the game is played over a period of time successive actions by the other players are followed after the previous round of actions has been observed in order to be able to discuss some peculiar features of these games[11].

2.3 Credibility and subgame excellence

At the heart of Nash equilibrium games with successive moves is the idea of reliability which leads to a refinement of the concept of equilibrium, in the sense of "credibility equilibrium".

The credibility game can be easily seen from the following simple two-player industry entry game. If location 1 is a potential candidate moving "in" or "out" if chosen, then the game ends and the payoffs are 0 for location 1, which is valuable for both locations 1 and 2 where the payoffs are 1 and 0 for each separately. represented in the image below.

Considering the strategy pairs that location 1 chooses, while location 2 chooses a strategy fight if location 1 chooses because it manages to see what location 1 is doing and can condition on this action. This is a Nash equilibrium, because given location 1 chooses location 2's strategy as the best response, without going either way. Additionally, site 2 threatens to fight as site 1's best response is to stay away, so both strategies are joint best responses. There is something unattractive about the previous result or at any rate something impossible about the threat of contention from site 2 considering that site 1 wanted to test this threat. Such reasoning yields the answer that it does not: contention allows a payoff of 0, where reckoning allows a payoff

[10] Ibidem, strana 766- 767
[11] Ibidem, strana 767

of 1. The only possible course of action for site 2 is to adjust to the entry, and if site 1 knows this, it will enter, thereby following the concept of the Nash equilibrium is insufficient, it makes the "equilibrium" impossible which lacks credibility.

This motivates a refinement of the concept of the Nash weight that is very apparent in the image where it resembles a tree. In this example the tree is very simple - there are only two mangers - but we can imagine 1 moves and then 2 and then player 3, or even players 1 or 2 in further moves and so on where we will have a tree with many nodes. Let's think of a minigame or subgame that results for each and every one of these nodes, which will occur if, for some reason, the players have to arrive at these nodes due to accident or plan.

Credibility simply says that all strategies must be the best response to other strategies, for the original game, but starting from any game, that is, the strategies must be Nash equilibria for each subgame called strategy combinations of the subgame Nash equilibrium.

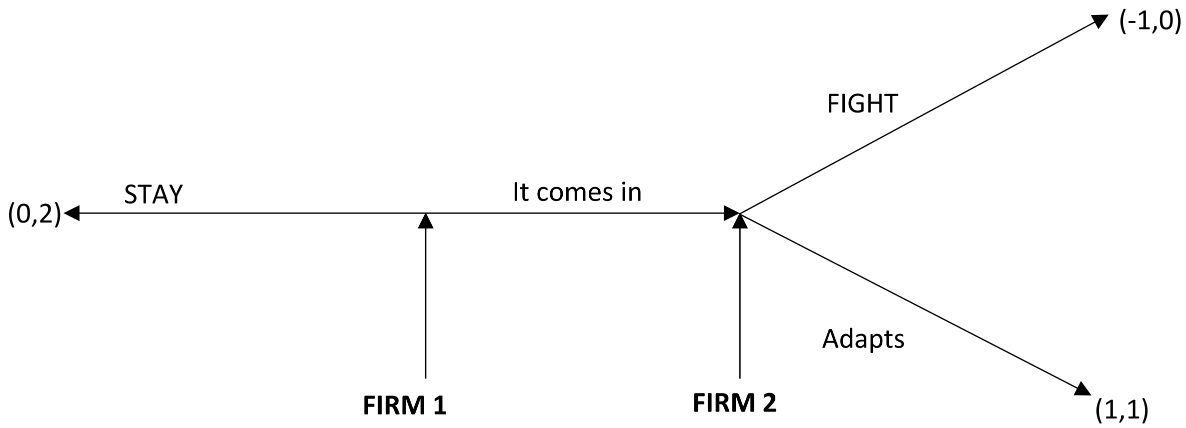

Figure 4, Credibility: drawing[12]

In our example, the functioning of the strategy pair does not include the best response to the (unique) subgame of that example, so this strategy pair is not a perfect subgame. There is another strategy pair that satisfies the needs: it is the combination made of the joint best contracts in both subgroups and is thus a perfect subgroup of the perfection theory of the nascent industry.

As part of protecting the industry, the monopoly industry is protected by tariffs to cut costs and achieve international competitiveness. After making the decision, the government is looking at costs and cutting them before deciding whether to remove the industry-protecting tariff.

To analyze this model, four modes are considered:

- The free trade regime has cut costs with competition on the world market
- A low-cost protectionist regime with no need for industrial survival
- The regime of free trade with high industrial costs, which is not competitive and the product is exported

[12] Авторска слика, Ibidem, strana 768

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- A protective regime with high prices from international competition and supplies the domestic market.

The figure below describes a situation in the form of a game tree where the initial move is by the government (not shown on the tree) where protection has been granted to the industry for a period of time to decide whether to lower prices or the current highly competitive level. Following the industry's decision, the government must decide whether to withdraw protection. After the government's decision, one of the regimes described earlier comes into existence that connects the regimes to different end nodes of the tree with payoffs to the players in the game: industry and government. The first entry represents the payment to the industry and the second entry represents the payment to the government. Let us first examine the payments to the industry starting from what they want most, which is not to cut their costs and retain full protection. This is a case of having someone else's cake and eating it too, and this option causes 150 if costs are not cut to just remain unprotected with the lowest payoff of 0. Cutting costs and being protected is the next best alternative, at 125, after cutting and being competitive without protection (the mode 1 case) comes to 100, which is well below the pampered option of an inefficient and unproductive method.

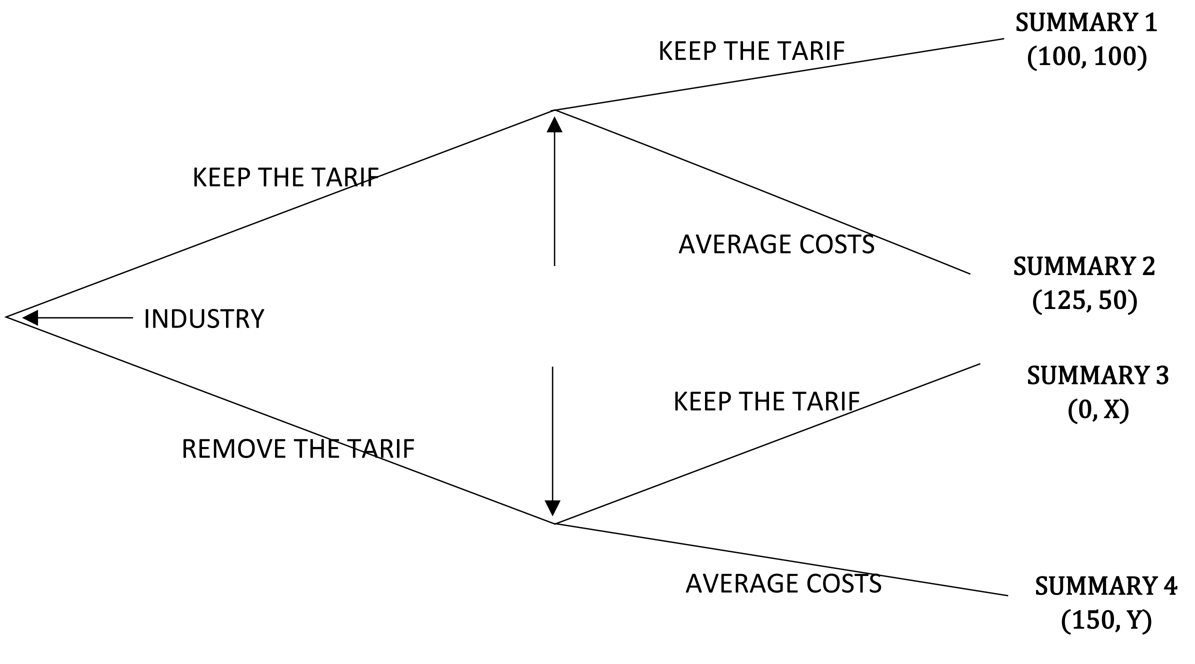

Figure 5, The Protectionist Game[13]

What happens with the privileges of the government is seen clearly in regime 1 which is preferred by the government, from regimes 2,3 and 4 where the industry is fully competitive and free for the benefit of the consumers without dangerous contraindications. In regime 2, the industry does not need protection, the government knows that the industry will survive with or without protection and withdraws it with the protection. So we give the government payoffs of 100 to mode 1 and 50 to mode 2 regardless of whether the government prefers mode 3 to mode 4 which have high prices. Mode 4 allows protective profits to the domestic producer, while

[13] Авторска слика, Ibidem, strana 769

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mode 3 actually gets rid of it and is preferred over mode 4 by all consumers or users of the product that is marketed cheaper than the world market. The government's final preference for these two regimes of conflicting interests is denoted by the payoffs X and Y: where both are less than 100, and their relative importance are crucial to the success or failure of a protective policy designed for lower costs.

The analysis of the model continues in the industrial strategy with a simple action to cut or not to cut costs, but the government strategy is more complex with a conditional statement about the reaction to each of these two actions. An example of a strategy pair is to cut costs, with no tariffs and regardless of whether the industry cuts costs or not, which is always a Nash equilibrium, regardless of the values of X and Y. In such strategies the government adopts the strategy of removing tariffs regardless of industrial action as industry faces payoffs of 100 if it cuts costs and 0 if it does not as shown by the tree in the previous figure. Industry cost-cutting is adopting a cost-cutting strategy, and the government is finding it worthwhile to remove tariffs that raise the question of the reliability and excellence of the subgame.

In response to the dilemma posed, we must examine all possible subgames when the industry does not cut costs. In this subgame, the government's strategy of removing tariffs with the plausibility if X>Y where the consumer's interest must play a greater role than the producer's interests in determining government policy when the government can convincingly punish it with an interest to do so ex post.

In the case where Y>X the interests of producers have a larger development in the government's calculation that destroys the credibility of the tariff removal theory because the relevant subgame does not contain the best response. In this situation the government cannot get the budding industry to cut costs and possibly increase its growth.

In the case where Y>X, the only subgame perfect Nash equilibrium is one where the government chooses the strategy of removing the tariff if it cuts costs, which imposes the opposite situation of keeping the tariffs and the industry does not cut costs. Through this example as part of the subgame, we learn that the player-government's ability to achieve goals may depend on its advantages over other alternatives, none of which are necessary for what it ultimately wants to achieve[14].

2.4 Agreements

Principal mediator models depict sequential games where one principal group moves first by offering a deal to the other group, the broker of a deal that can be coerced. The mediator then reacts with an action that cannot be monitored or reassigned under the influence of the form of the contract.

The following text will discuss an example of loan coverage for the construction of a sports-school airport. In such a situation, the lender is the main one, who offers a loan agreement that dictates the terms of the loan, i.e. interest rate. The intermediary, the lender, chooses a size of the stake on which the contract depends, where as an alternative possibility is the land lease contract. The owner leases the land to the tenant under a contract, which is a scheme of division

[14] Ibidem, strana 767- 771

of the produced result. This is a characteristic function of different score levels between landlord and tenant. After the contract is offered, the lessee chooses a quantity of labor where we use the concept of subgame perfect equilibrium to analyze the contracts. If we consider the land lease agreement, the tenant can adopt the following strategy where according to the importance of the agreement, he will choose the effort level equal to zero. If the landlord believes in this strategy, he offers a special contract so this strategy combination has the subgame perfection disadvantage that if the tenants are faced with a contract in which he threatens to exert zero effort, it follows that nothing will be realized. In such a case, the level of effort that is most favorable for the lender is given in the contract, so the correct solution for these games is for the manager to calculate the optimal level of actions instead of the intermediary. Finally, in each contract with this information, the manager has to choose the best possible contract for the motivation of the general structure of the principal intermediary model with unsupervised actions of the intermediary. If we look abstractly, we can imagine that the agent can choose from the set of actions A, which is not assigned by the manager, so that the final result is a function of the chosen action under the influence of stochastic shocks, written as:

$$\gamma = F(a, \theta)$$

where Y is the value of the result, and is the action chosen by the intermediary and O is the realization of some random shock, where in our case it can be unfavorable meteorological conditions that can significantly affect airport operations.

The contract as a strategy by the manager represents the function R(Y) that describes the agent's reward for each level of output Y when the agent chooses an action a from group A, and if there is a utility function u(a,R) depending on the action and its reward in order to increase the expected value of u=(a,R) , where R=R(Y) and Y according to the presented image.

The manager knows that the broker behaves according to the picture presented above for each offered contract, according to a manager function of v, with the function R (Y) to

increase the expected value of v (Y-R(Y)), where Y is determined from the image and a is determined from the result of the image represented as stimulus retention. Other constraints in the manager's choice of contract mean that it should be ensured that the intermediary receives a certain minimum benefit from the contract, and if not, his participation is limited. Further constraints on the augmented problem require that the intermediary benefit should be at least some target value, represented as the intermediary's estimate of his next best option as a manager-intermediary problem.

According to the owner-tenant example, we showed that this is a special case of the manager-intermediary problem with an algebraic solution for the most favorable land lease agreement when the intermediary is assumed to be risk neutral[15].

2.5 Repeated games

As another type of intertemporal games are repeated games where we start with the assumption that a group of players is involved in the game. In this game we will imagine it as a giant game

[15] Ibidem, strana 771- 773

in itself and that it is played again and again by the same group of players, that is, that it is repeated. Specifically, the individual games that are made up of a giant unrelated game where the impact of the minigames is overlooked by the player pool that can be realized in other minigames and involving the same connection in the future.

To illustrate the above, we will consider two players involved in a repeated prison's dilemma game with a tabular representation of the prison's dilemma characteristic:

	COOPORATE	MISTAKE
COOPERATE	10,10	0,15
MISTAKE	15,0	5,5

Introducing the concept of a mental horizon through the idea of each player having some degree of foresight, it is absurd to imagine that each player only cares about the predicted date. In such a situation, thinking about future payments is more realistic, in which they remain concerned about payments regardless of whether they are in the near or distant future. The easiest way is to assume that the player cares about N periods in each time period, so if N=1 then he is short-sighted and only cares about today's winnings. If the increase in N is to gain, the player's mental horizon increases.

Consideration of the theory of equilibrium will continue with digressions of reductions. Mental Horizons is easy but a bit non-standard, so for completeness we'll include the standard formulation with the assumption that each player puts some weight on the future, which is bounced further into the future which adds two advantages that compensate for its added complexity. The first adds that future concerns do not disappear suddenly, but gradually as we move into the future, and the second adds that service valuation through two adjacent periods is dependent starting from today and towards the future. For a complete representation we formally complete the construction by introducing a reducing factor b, where $0<b<1$ replaces today's payouts with today's payout of t periods of b so that the relative weight across each pair of adjacent dates is always b.

For the exact formulation of the mental horizon, we use the idea that cooperation in repeated games from the implicit threat of withdrawal of non-cooperation of the repeated game from the result. In such a situation it is independent of the past history of the subgame perfect equilibrium of the repeated game where one player's strategy is always to concede regardless of players when it is in the interest of the other player.

The idea of this equilibrium in interest is to try to construct another equilibrium of the repeated game, as a perfect subgroup considering the following strategy when each player cooperates in all subgames as part of the total cooperation. In every other subgame, play withdrawal suggesting a perfect subgame equilibrium where total cooperation has not occurred in the past, due to the discussion already elaborated.

It only remains to check that the joint best answer is satisfied together with the cooperative subgames assuming that we are in such a subgame and the player entertains the possibility of deviation with a game disadvantage thereby forcing the game to (withdraw, withdraw). With a mental horizon of N periods, the following calculation is relevant to the payoff matrix:

- If withdrawn, to receive a total of 15+ 5(N-1)
- If he cooperates to get a total of 10N.

A different formulation than the above is that withdrawal imposes a gain on retaliation as the other player changes actions according to a given strategy that ensures a (10,10) payoff in each period so the player cooperates if 15+5(N-1) <-10N or, equal, if N>-2. According to this if each player cares at least as much about tomorrow as about today, cooperation is plural in the repeated game even if it is not possible in the game phase. The N needs will vary with the payoff matrix in the game where with the reduction version it is possible to provide a measure of the minimum degree of foresight required[16].

2.6 Basic concepts

The most basic way to describe a strategic situation or game is to go through this section to truly understand it. Suppose you have a group of individuals, or players with names of each player with index I, player i will address player i with index i with different objects with indexes like 1,2,i, j...

For each player i, we have a group of strategies, in our case the characteristic strategy of this group can be denoted as S1 with a list of strategies (S1, S2...Sn), one for each player. To shorten our notation, for a strategy profile is S, each player i receives a payoff ui that may depend on the full vector of strategies in that profile, we sometimes refer to ui as ui(s) to emphasize the fact that ui is function of s, for each player i.

Our game script seems to be finished, but of course, what we have so far looks falsely simple. There are many types of games that fit into this framework, and to understand the various concepts we've been introduced to so far we'll explain our example of choosing an airport location. First, a strategy can mean many things and may or may not be described as a single number and may stand for a list of actions dependent on various contingencies. Second, payoff can mean: the individual's satisfaction or benefit, the monetary reward he or she receives, the expected value of the monetary reward or benefit in a particular situation. Here we have our example for illustration[17].

2.7 A model of sustained growth of a sports-school airport according to the Nash equilibrium

The basic model of supply and demand is the basis of microeconomics and allows us to understand why and how prices change and what happens in the market to determine how to develop an airport according to the concept of sustainable development. The supply and demand model relates 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 factors constant shown on an "S" curve graph. The vertical axis of the graph shows the price of good

[16] Ibidem, strana 773- 775
[17] Ibidem, strana 757- 759

'P' for a given quantity supplied. 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,

$$Q_s = Q_s(p)$$

The demand curve is the number of goods to be purchased at a given price and the relationship between quantity demanded and price can be written in the form of the equation:

$$Q_d = Q_d(p)$$

The demand curve is denoted by D and has a negative slope, decreasing. Consumers are usually willing to buy more if the price is lower, which encourages the consumption of larger quantities that make them readily available to those who are overpriced. There are two curves at the point of equilibrium or equilibrium of prices and quantities, where in addition to the price Po the quantity equals the quantity demanded Qo. A market mechanism is a trend in a free market in which the price changes until the market is balanced and the quantity supplied and the quantity demanded are equal. The market tends to balance as a result of a surplus, meaning "quantity supplied in excess of demand" and a deficit, meaning "less than quantity demanded", resulting in the supply of the required quantity not being available. to consumers more. Supply and demand curves shift over time and as a result of changes in market conditions where changes in price and quantity depend on shifts in each curve. A measure of elasticity measures the sensitivity of one variable to another, a number that tells how much percent one variable will change if the other increases by an amount Q and a value P. This expression can be written as $E_p = (\%\Delta Q) \ / \ (\%\Delta P)$and means that the percentage change $\%\Delta Q$, means percentage change Q but $\%\Delta P$, means percentage change P''.

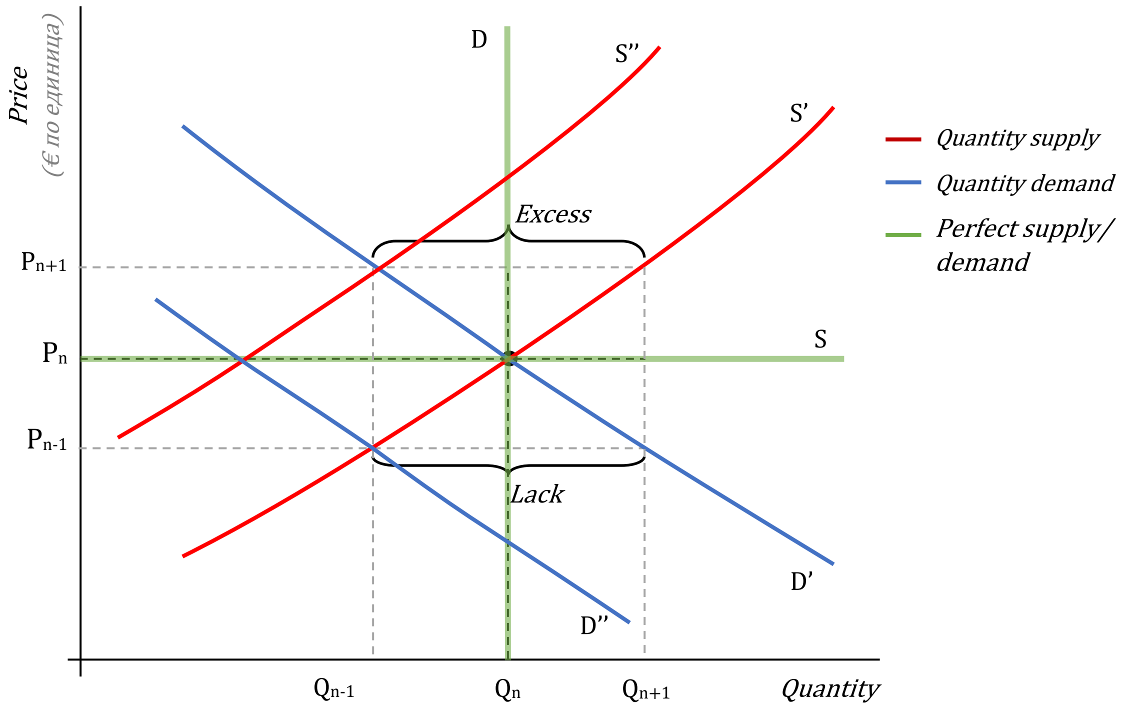

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Figure 6, Supply and Demand Curve, Equilibrium System[18]

The percentage change in a variable is the absolute value of the change divided by the original level of that variable, where the elasticity of demand is represented as

$$E_p = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}} = \frac{P}{Q}\frac{\Delta Q}{\Delta P}$$

The price elasticity of demand has a negative value when the price increases and the quantity demanded decreases, hence $\Delta Q/\Delta P$ is negative, as well as Ep which contributes to the increase of the airport category. When the price elasticity of demand takes a value greater than 1 $(E_p > 1)$, the decrease in quantity demanded 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.

The price elasticity of demand depends on the availability of other goods and possible substitution. If there are substitutes, then the increase in prices will lead the consumer to reduce the supply whose price has already increased and increase the supply of substitutes, and the demand will be very elastic. If there are no substitutes, demand is inelastic. The price elasticity of demand measures how much the quantity demanded will change when the price changes. It is the percentage change in quantity demanded divided by the percentage change in price. Economic demand determines the price elasticity of demand for certain goods. Price elasticity of price exists when there are substitutes A and when consumers have more time to adjust their behavior, on the contrary, elasticity is lower in the short run in the case of necessities and goods with few substitutes. The price elasticity of supply is the percentage change in quantity supplied divided by the percentage change in price[19].

3.0 CONCLUSION- EQUILIBRIUM THEORY

Airport size is a fundamental problem to be solved through sustainable development. One way to compare different systems is how different systems approach their solution. Among the most important problems of this kind is the problem of the equilibrium of the economic system as a whole or the so-called general equilibrium and equilibrium system. The economic system is a complex entity consisting of a large number of interdependent elements. The concept of balance is a basic organizational concept that connects a series of complex interdependent and functional relationships into a single whole. The connection between natural sciences and economics is particularly clear in the conception of economic society as a deterministic system. The idea that a social system with different goals is consistent with a final coherent state of equilibrium, as a state in which the results of the actions taken can differ significantly, is an important achievement with which economic thought contributes to a better general understanding of social processes. . The general interdependence of the elements of an economic system as well as their horizontal and vertical connection in the realized social division of labor form the starting point of the content aspect of the balance problem. Horizontal

[18] Graph 1: author's image, Strateški menadžment, Arthur A. Thompson, Jr.,A.J.Strickland III, John E. Gamble, MATE 2008

[19] Dynamic General Equilibrium Modeling, Burkhard Heer, Alfred Maussner, Springer, 2nd edition, 2009

connection means the interdependence of production and personal consumption, while vertical connection shows that the volume of production within one branch occurs as a prerequisite for the functioning of another. Both types of relationships have their own qualitative and quantitative form. In order to evenly satisfy the needs for personal and productive consumption, it is not important to achieve the volume of the gross domestic product, but also its qualitative composition. It is a basic prerequisite for a continuous process of social reproduction and forms the essence of the content aspect of the general economic balance. This means that every economic system faces problems of organizing the exchange, as well as coordinating the individual decisions of the bearers of economic activity in production and consumption.

Phenomenological conceptions represent the economic balance as a unity of many that are not determined by any general law but as a possible and probable occurrence. Here, equilibrium is understood as a general phenomenon that can be so generalized that it can be analyzed outside the context of a particular socio-economic system, i.e. isolated from the institutional framework. The presentation of causal relationships is replaced by the presentation of functional relationships so that the logic of formal microeconomic models corresponds to these concepts, the content of which can be mathematically formalized. Some modern methodologies of economic balance are also close to phenomenological concepts, which: deal primarily with macroeconomic, aggregate economic quantities such as savings, investment, national income, consumption, production, etc. These quantities are seen as empirically given and certain equilibrium relationships and assumptions are formulated for them, such as Keynesian and monetary equilibria. General equilibrium models provide a way to analyze the interactions of individuals and firms in a market economy. The basic components of the general equilibrium model are quite simple: agents maximize utility subject to budget constraints, firms maximize profits, and clear markets. It is obviously interesting to see how these essential components of the general equilibrium model constrain market behavior.

Strategic decision making with game theory can answer the questions of running an airport to successfully match supply and demand.

Game theory extends the analysis of strategic decision-making to significant advances in microeconomics. Key aspects of this theory are used to understand market development and functioning and how to think about strategic decisions. To clarify terms: a game is a situation in which players make strategic decisions that take into account the actions and reactions of their game partners. Airport games compete with each other by setting prices for consumer purchases where strategic decisions end up with a result that generates rewards or winnings. For the airport, the return is profit. The main goal of game theory is to determine the optimal strategy for each player, and strategy is the rule or action plan for playing the game. For an airport with certain prices, a strategy is possible: it will maintain a high price just like its competitors, but when someone lowers the price, it will lower the price even further. Bidders sometimes have a strategy: the first bid is x euros, but I give up if the others raise more than 4x euros. The optimal strategy for each player is to maximize the expected return. An economic game company can be cooperative or non-cooperative. In a cooperative game, players make binding agreements about joint strategies, while in a non-cooperative game, it is not possible to negotiate or enforce binding agreements. The fundamental difference between a cooperative and a non-cooperative game is the ability to negotiate, while in any game the most important aspect of strategic decision-making is understanding the opponent's point of view, assuming that the opponent is rational and anticipating a possible response of appropriate actions. Even in simple game situations, the opponent's attitude and rational reaction are often overlooked or misjudged. Some strategies are successful if competitors make certain decisions. The concept of a dominant strategy is optimal regardless of the opponent's actions, while a balance is a dominant strategy when each player has a dominant strategy. A Nash equilibrium is when each player has a strategy to do the best he can, as does his opponent, and since no player deviates from his Nash strategy, the strategies are stable. The Nash Balance is achieved by advertising in the three locations: with the best possible decision and no incentives to switch where each airport achieves the highest possible profit at its competitors' prices, with no incentives from competitors to switch prices.

The parameters provide the data needed to specify the role of the domain in determining the general equilibrium solution for prices and quantities. This solution has one essential feature: there must be no unsatisfied demand by production and consumption for input or flight output services. Analysis of the balance of supply and demand for flights requires specification of the behavior of resource owners in their role as consumers. Analysis of the balance of supply and demand for flights requires specification of the behavior of resource owners in their role as buyers. Central to the discussion is the concept of the budget set which defines alternative consumption packages of individual factors and prices for inputs and outputs; preferences determine the specific choice made. Thus, the total demand for each good depends on consumer tastes, price factors and the good, as well as on the given allocation of resources among consumers. General equilibrium requires that prices for factors and flights be such that the total demand for each flight does not exceed its total supply. The offer, however, is subject to the condition that the relative price ratio does not exceed the corresponding opportunity cost ratios. It follows that: equilibrium allocates resources depending on the simultaneous resolution of a whole set of relations: resource constraints, price constraints and equilibrium conditions in supply and demand for the goods under analysis[20].

3.1 Nash equilibrium

С т р а т е ш к и о т A strategy profile is a set of strategies, one for each player, where the strategy profile is a Nash equilibrium if and only if no player can do better in the event that 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 a player reacts positively then it is not a Nash equilibrium. If each player prefers not to switch, then the strategy profile is a Nash equilibrium where each Nash equilibrium strategy is the best response to the other players' strategies.

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

$$u_i(S_i^*, S_{-i}^*) \geq u_i(s_i, s_{-i}^*) \; for \; all \; s_i \in S_i$$

[20] Ibidem

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If the equilibrium is unique, it may be weak, meaning: a player may be indifferent between several strategies to other players. A very unique Nash equilibrium is if the inequality is severe, so that the single strategic best response is: $u_i(S_i^*, S_{-i}^*) > u_i(s_i, s_{-i}^*)\ for\ all\ s_i \in S_i$.

The strategic set S_i may be different for players, and its elements different for mathematical subjects where the player chooses between strategies, and $S_i = \{Yes, No\}$. A set of strategies can be a finite set of conditional strategies in other words $S_i = \{Yes|p = Low, No|p = High\}$S i = {Yes, No}. {\display style S_{i}=\ {Yes, No\}.} which can be an infinite set of $S_i = \{price\}$. such as a positive real number. Nash Evidence assumes a finite strategic set of requirements that sometimes appear irrational from a third-party perspective because the Nash Balance is not necessarily Pareto. It can have irrational consequences in subsequent games as players "threaten" each other with threats they won't make, which can be important as an analysis tool[21].

3.2 Strong-weak equilibrium

If in a Nash Equilibrium, each player asks, “Knowing the strategies of the other players, should they change their strategy?” If each player's answer is “Yes,” then it is a strict Nash equilibrium. If there is an exact equilibrium between the Nash equilibrium strategy and some other equal wage strategy, then it is a weak Nash equilibrium, which in turn can be a pure strategy or a mixed strategy[22].

3.3 Theorem for the existence of our Neash Equilibrium

Nash proved that if mixed strategies are allowed, a game with a finite number of players choosing between finitely many pure strategies has a single Nash equilibrium, as a pure strategy for each player with the probability distribution over strategies for each player equally. A Nash equilibrium does not exist if the choice set is infinite and non-compact, and it exists if the choice set is compact with constant payoffs 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 when each of the two players chooses a real number, strictly less than 5, the winner is the higher number.[23]

3.4 Network traffic

In a network graph, the edge values are the travel times 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 "airplanes" traveling from A to D.

[21] https://en.wikipedia.org/wiki/Nash_equilibrium
[22] https://en.wikipedia.org/wiki/Nash_equilibrium
[23] Ibidem

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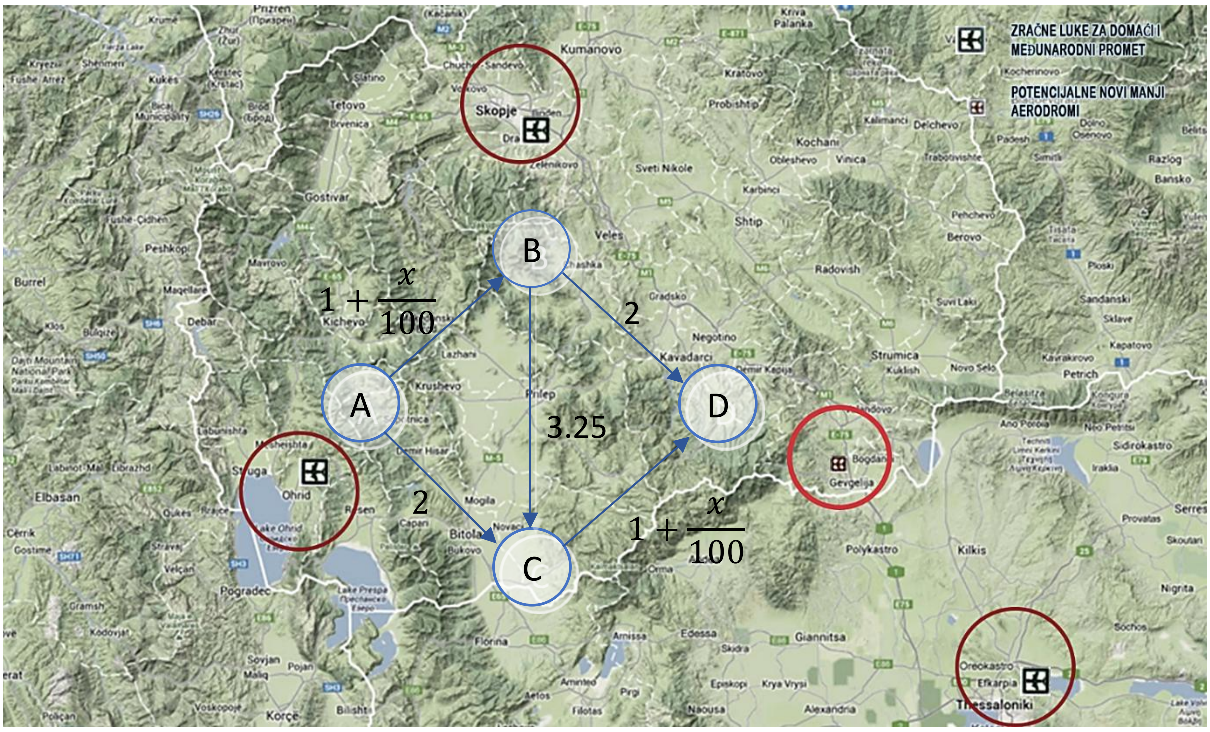

A – OHRID AERODROME, B – SKOPJE AERODROM, C – SOLUN AERODROME,
D – PLANNED AERODROME IN GEVGELIJA

Figure 7, Locations of existing airports in the airspace[24]

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 "payoff" of each strategy is the travel time of each. the route where the plane travels through ABD exceeds the travel time of (1 + x / 100) +2, and x is the number of planes along edge AB. The payoff for any given strategy depends on the choices of the other players, and the goal is to minimize travel time. Equilibrium occurs when all track times are the same and no pilot has an incentive to change lanes, as this increases travel time. If out of 100 planes travel from A to D, each passenger now has a total travel time of 3.25 which leads to the conclusion that this allocation is optimal. When 25 aircraft choose the route ABD, 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 a balance in another possible way reducing the efficiency of the system known as the Braes Paradox[25].

3.5 Airport Development

Due to the complex socio-economic factors, it is necessary to determine the construction phases in the development of the airport site. In addition to the physical geographical characteristics of the planned development and the influence of other elements, here comes the expressive

[24] picture 2: author's image, source: google earth
[25] Ibidem

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degree of development and urbanization of the city. The level of development that the airport can develop and how many years the need for a larger airport will increase will take into account the identified and planned routes and economic viability.

In the city and in the region there is a lack of a small and medium airport, which will be open throughout the year, due to the favorable weather conditions, in the first phase a grass route of USS is planned. Grass USS is planned in order to confirm all the conditions that have already been developed due to being a grassy American association, the airport in Gevgelija will operate for about 10 months, which means that the needs of mostly sports and school aviation can be met by commercial services. can be provided in the second year after construction.

The potential site, in addition to meeting all the conditions for the construction of the reference code of Airport A1, meets the conditions and satisfies the need for further development. After construction, for a certain time of use, confirming the established parameters and in practice, despite the fact that the location is the most favorable, it gives the opportunity for further development, such as the extension of the maneuvering surfaces of the asphalt runway, associated buildings and surfaces. To achieve airport conditions all year round and in poorer visual conditions, the recommendation is to widen and build the USS with an asphalt runway, of course the maneuvering and movement areas will be merged. Due to the limitation of summer activities only in the visible part of the day, it is recommended to meet the conditions for night flying. This of course means that the equipment, the night markings, have to be increased to keep the maneuverability and other areas at a higher level. These financial investments will contribute to the further development of air traffic in Macedonia and the development of the region itself and Gevgelija as a center[26].

4.0 ADDITIONAL PART- GAME THEORY REPRESENTATION OF SITE CHOICE FOR SUSTAINABLE DEVELOPMENT

In project management, game theory is used to model the decision-making process of players, which is critical to the success of projects, and to make scenarios suitable for game theory modeling. The developer usually has several options given as L1, L2 and L3 that are likely to result in a different project and must decide how far it is necessary to push the project case without jeopardizing the entire project. The main decision is the best timing and strategy for developing the category, so that it can gain maximum traction in terms of benchmarking during the implementation process. In each of these locations, the necessary decisions depend on supply and demand decisions, have competing interests consistent with the benchmarking process with the decision maker's interests ideally modeled by game theory.

To allocate a specific location that maximizes the level of category knowledge and profit, the category development index can be expressed by the equation:

*CDI= (Percentage of total product category: Percentage of total project estimate) *100*

When choosing a location for the airport in Gevgelija, in the design zone, it does not face the problem of obstacles at higher altitudes, which gives the builder a very feasible task and simple

[26] Aerodromes, Annex 14 to the Convention on International Civil Aviation, Volume I, Aerodrome Design and Operations, International Civil Aviation Organization, Fifth Edition, 2009

field work. The choice of location is L3, which due to its geomorphological composition is ideal for such facilities. The overall current political and social situation, as well as the development of air traffic, justify this choice of airports for sports schools.

Figure 8, Steps for airport development[27]

The object during the selection satisfies the need to serve in the coming years without major modifications and thus justify the idea of creating and investing funds, as well as enabling development according to the requirements. Taking into account the correctly assessed topographic features, the very favorable meteorological position, the proximity to the surrounding airports, facilities and other resources, it can be said that the choice of location is suitable for realization.

The choice of location is feasible, expected and tolerable in terms of the following structural, institutional and financial consequences in the region of Gevgelija, a choice that meets the basic conditions for the most favorable location that is sustainable without the possibility of an unexpected or uncontrolled failure.

Game theory as the study of a mathematical model intended for strategic selection by rational decision makers is used to represent locational decisions where the level of development according to sustainable development and benchmark knowledge is made to make final decisions. The choice of three locations L1, L2 and L3 will be discussed through the example of a simultaneous game with three locations where each location has two options, L1 has two moves, L2 has B1 and B2, and L3 has C1 and C2. The results of L1 are represented in the first entry of the upper left cells in both matrices is 0.1, the highest first entry of the upper right cells is 1.1, and we get 1 respectively 0.1 for the lower left cells, that is, the lower right cells. The second highest entry in the first column is 0, in the second column it is 1.1, in the third column 1 and in the fourth column 0.1. For L3, the highest third entry in the first row of the first matrix is 2.1 and in the second row of the first matrix is 1. In the second matrix the third highest entry in the first row is 1.1 and in the second row is[28]

[27] Figure 3: authors picture, en.wikipedia.org/wiki/Category_management#/media/File:8-step-process.png
[28] https://www.maa.org/sites/default/files/pdf/ebooks/GTE_sample.pdf

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The development of the balance system in parallel with the establishment of a balanced supply and demand within and as an integral part of the concept of sustainable development, in accordance with the requirements for the development of the airport, is the subject of thematic processing. The limited resources used in modern general aviation airports and the need for development in accordance with the concept of sustainable development, constantly open new promising applications of game theory in solving various problems related to this topic.

Most of the problems are related to the optimization of allocations for the change of supply and demand and the management of the category of the airport corresponding to the category A1. The Nash equilibrium represents a starting point from which no player has any interest in exiting. Here are the basic ideas for sustainable airport development with processes such as benchmarking analysis. Finally, "as you will find in multivariable calculus, there are often a large number of solutions for any given number." John Forbes Nash and the category problem of this airport is solved as is the dilemma of which factors should lead to the final conclusion in problems like this[29].

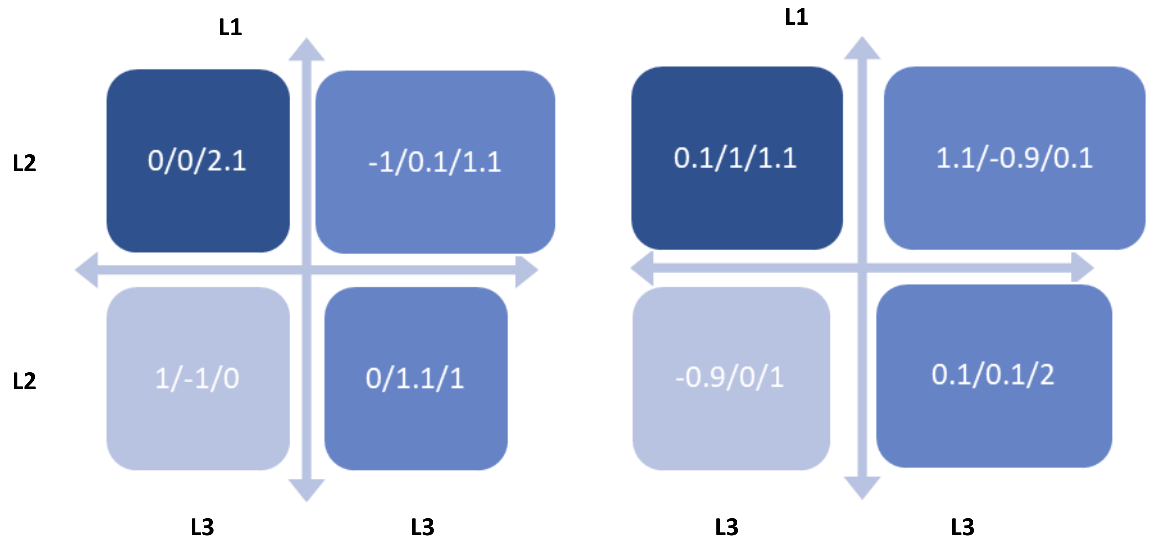

Figure 9, Game theory matrices for location selection[30]

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[29] https://en.wikipedia.org/wiki/Game_theory

[30] Figure 4: authors picture, https://www.maa.org/sites/default/files/pdf/ebooks/GTE_sample.pdf

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