

Social and Economic Effect Estimation of the Cycling Development of Azerbaijan

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Abstract— This study aims to estimate the social impact of the development of bicycle usage by citizens and the partial effect on the cars use on the example of Azerbaijan. The authors review experience of bicycle usage to found out main contributing factors to the development in this sector. Moreover, in order to implement the state program of the Republic of Azerbaijan for 2019-2023 and promotion of bicycle usage, an example is given of a significant leverage necessary for its implementation. Using a regression analysis, the authors analyze the impact of environmental and social factors? As well as the level of air pollution and life expectancy on the number of bicycles from 2005 to 2017. Results indicate a possible social effect and social impact of bicycle usage on the well-being in Azerbaijan. Based on empirical results the authors propose policy recommendations to promote bicycle usage in Azerbaijan.

Keywords— *bicycle, life expectancy, econometrics, bicycle route, road density.*

I. INTRODUCTION

Improving road infrastructure, expanding roads in a short-term period might help to reduce the level of traffic. However, such policies may cause even more car overload, which, in turn, again may worsen the roads condition.[1]. Switching to an alternative mode of transport can increase the level of safety on the roads and reduce the number of deaths from traffic accidents [2]. A bicycle is one of such those modes of transport.

II. THEORETICAL FRAMEWORK

Cycling improves the viability of cities, human health, reduces the pressure on the environment [3], leads to significant economic boom, and also creates a number of other favorable social conditions. This is very promising mode of transport which provides a large number of economic and social benefits, including jobs creation.

It was estimated that, cycling generates number of vacancies appear in five different sectors of the economy [4]:

- Bicycle trade (mainly sales and repairs),
- Bicycle industry (production and wholesale)
- Bicycle infrastructure,
- Bicycle tourism (accommodation and restaurants) – people enjoy cities with a great bicycle culture, because they are less crowded, less noisy and the air is less

smog-burdened. In addition, many countries are discovering the economic benefits of cycling. The development of interregional relations is a weighty argument in favor of cycling [5].

- Bicycle services - operating costs for the existing services for trucks are reduced, replacing some trucks with bicycles, which also favorably affects the speed of delivery services, reducing the number of cars on the roads.

The bicycle provides mobility over short distances. According to the State Statistical Committee of the Republic of Azerbaijan (SSCAR) the average distance traveled by a car by one person is about 14 km in 2017. Taking into account these figures, we came to the conclusion that a large proportion of trips in our country occur over short distances that can be covered by bicycle, especially during rush hours in order to avoid congestion. Such turning capacity of cycling provides an opportunity to create new local jobs, especially more jobs for low-skilled people[6].

Other than creation of new jobs, the use of bicycles also improves quality of life, and this, in turn, labor productivity [7]. According to numerous studies people who come to work on a bicycle work more productive than people who came by car or public transport. The psychological effects of riding a bicycle [8] are mood improvement, stress relieve, and suppressing negative emotions; in other word, it is a strong anti-depressant [9]. In addition, the bicycle is a means of getting rid of cardiovascular diseases, diseases of the lungs and respiratory tract and their prevention [10]. According to WHO (World Health Organization) in 2018, 91% of the world's population lived in areas where the level of pollution exceeds the values set in the WHO air quality guidelines. Reduction of air pollution, according to WHO, can be achieved if, for example, the average annual value for nitrogen dioxide, poisonous gas, which is part of the gases released from exhaust pipes of automobiles, is $40 \mu\text{g} / \text{m}^3$. According to SSCAR, in Azerbaijan, and in particularly in Baku, since 2007, these figures ranged from 50 to $70 \mu\text{g} / \text{m}^3$, and even in 2010 approached to the level of $90 \mu\text{g} / \text{m}^3$. In 2018, the average annual value for nitrogen dioxide was $70 \mu\text{g} / \text{m}^3$, which is 75% higher than the benchmark level.

III. INTERNATIONAL EXPERIENCE

One euro invested in a bicycle gives the society 450 euros of aggregate economic effect. This calculation was carried out by scientists from Germany, and there is no doubt about its accuracy (Yanyshev, 2014).

In addition to Germany, we have compiled a chart of statistics from the other 9 countries with the highest percentage of cyclists among other countries of the world:

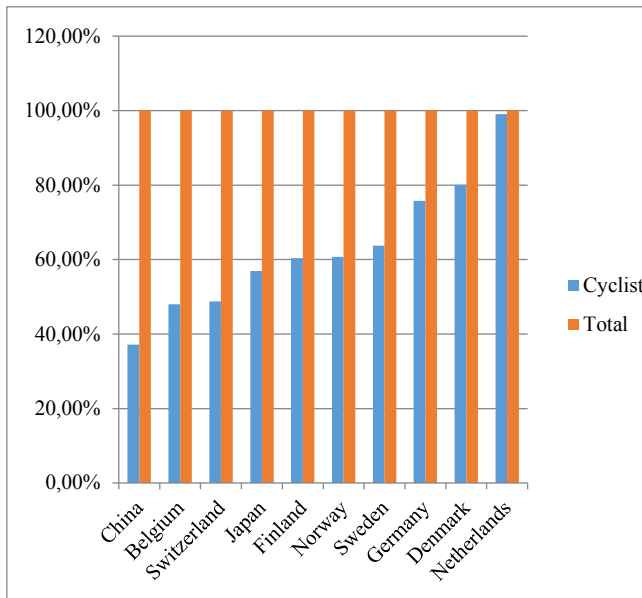


Fig. 1. Percentage of cyclists as a share of the total population in countries with developed bicycle infrastructure

As can be seen from the diagram, the countries with the largest percentage of cyclists among all residents are developed countries, which is not a coincidence. Taking into account such a popularity of bicycle usage, the European network of cycling routes project Euro Velo has been founded in November 21, 1997 with the aim of to promote development of cycling tourism and to introduce common road standards [11] Robert Coleman, Director of Transport for the European Commission, expressed that the hidden potential of international cycling can be realized with the help of an effective marketing strategy [12]. Today, this route covers almost the whole of Europe and new routes are being agreed upon, which increasingly cover the Eastern part of Europe.

As can be seen from the roadmap¹ of the cycle route, the accession of Azerbaijan to this project is inevitable in the future, since the route initially took its origin from the Western part of Europe and only then began to spread towards the Eastern part. The neighboring countries of Azerbaijan - Russia and Turkey have already joined this route. Obviously, to support this project country is required to invest large investments. But as the experience of European countries shows, a huge turn over bicycle sector pays for all costs.

According to the ECF (European Cyclists Federation), there are more than 250 million cyclists in Europe, of which 61 million use the bike daily. The economic effect of bicycles in Europe is more than 513.19 billion euro [13].

The bicycle sharing system (Bike Sharing) is gaining popularity and motivates to ride bicycles in the cities. The idea of introducing such system originates from the Netherlands. However, its first widespread use belongs to the United States, France, and Great Britain. Since 2013, among the CIS countries this system began to operate in Russia, Latvia, Lithuania, in Kazakhstan since 2014, in Ukraine since 2015. It is a system that allows a short-term (no more than 3 hours) trip around the city for residents and tourists as an alternative to four-wheeled vehicles [14]. The key convenient aspect of such a system is the close proximity of stations one another at any point where a bicycle can be returned (Qiu & He, 2018). So China, a country once known as the center of all cyclists, after the era of the "automobile society" with the advent of public bicycle market has regained the status of the country's cyclists [16].

Today, in many cities of Europe and North America, there is a new trend among people aged 20 to 30 years who move to the city centers, prefer compact buildings, prefer the bicycle and public transportation to cars [17]. Such a cultural shift will contribute to the growth of cycling in the future.

Transport economists around the world have developed a methodology [18] to determine the benefits of reducing congestion, such as reduction in car maintenance costs, parking costs, accidents and medical care, and reduced environmental impact. For some of these effects, estimating quantitative impact is difficult due to data limitation.

On December 27, 2018, the President of the Republic of Azerbaijan approved a decree on the creation of a state program² to ensure road safety in the Republic of Azerbaijan for 2019–2023 years. In subparagraph 7.4.1.4 paragraph 7.4 states the need to conduct promotion of traffic rules and use safety equipment, as well as the use of bicycles as an alternative mode of transport.

Our rough calculation suggests that only in 2017, there were about 64 thousand bicycles – about 7 bikes for every 1,000 people in Azerbaijan (for example in Switzerland - .451, Denmark - 780, in the Netherlands - 964 in world - about 330 in Russia - about 240 in Turkey - about 375 bicycles per 1,000 people). Today, a bicycle in our country is limited to use mainly as entertainment, sports, or as an alternative to expensive transport in rural areas. But it should be noted that there are other factors before deciding on the importance of the mass use of this type of transport in our country.

Considering the above mentioned points, we were able to determine the degree of importance of the bicycle as an effective policy to ensure safety and prevent deaths on the roads, and its role in environmental preservation, both for households and for Azerbaijan as a whole. In addition, we precisely found how much cycling depends on the density of roads.

¹<http://en.eurovelo.com/>

² STATE PROGRAM// Road traffic safety in the Republic of Azerbaijan for the years 2019-2023/
<https://president.az/articles/31388>

IV. METHODS

A. Positive environmental impact

This analysis was carried out using data on share of pollutants emitted by vehicles into the atmosphere and the number of bicycles and cars per 100 households in the form of a regression model (the method of least square, Eviews software), where the first parameter acts as a dependent. The dynamics was taken from 2005 to 2017.

TABLE I. DYNAMICS OF CHANGES IN THE NUMBER OF BICYCLES AND CARS PER 100 HOUSEHOLDS AND THE SHARE OF POLLUTANTS EMITTED BY MOTOR VEHICLES IN AZERBAIJAN

Year	Number of cars per 100 households, pcs.	Number of bicycles per 100 households, pcs.	The share of pollutants emitted by motor vehicles into the atmosphere, in %
2005	20.3	2.5	47
2006	21.2	2	61
2007	20.4	2	60
2008	19.9	1.8	69
2009	19.8	1.9	70
2010	23.4	1.9	78
2011	24.7	2.4	78
2012	27.1	2.3	79
2013	32.0	2.3	83
2014	36.0	2.4	84
2015	38.5	2.8	85
2016	36.0	2.7	84
2017	36.7	2.7	84
2018	37.0	3.0	85
2019	37.8	3.0	84
2020	39.4	3.2	82

B. Direct and indirect effects on human health

By the direct influence we meant the effect of bicycle usage as an improving physical fitness, and life expectancy. Indirect impact implies that this will lead to less use of the car and, consequently, fewer deaths from accidents (Pérez et al., 2017).

TABLE II. LIFE EXPECTANCY IN AZERBAIJAN (2005-2019)

Year	Number of bicycles per 100 households, pcs.	Life expectancy, year
2005	2,5	72.4
2006	2	72.4
2007	2	73
2008	1.8	73.4
2009	1.9	73.5
2010	1.9	73.6
2011	2.4	73.8
2012	2.3	73.9
2013	2.3	74.2
2014	2.4	74.2
2015	2.8	75.2
2016	2.7	75.2
2017	2.7	75.4
2018	3.0	75.8
2019	3.0	76.4

Life expectancy was chosen as an indicator of people's health. Effects of cycling were reflected in the regression model (the method of least square) with statistics for 2005-2020.

C. Road density as a leverage

As already mentioned, Azerbaijan, due to its geographical location, can easily join a single European bicycle network. However, to implement this project, one location is not enough. In the foreground the policy aimed at providing a safe route for a potential cyclist [19] and, accordingly, on the development of bicycle infrastructure. It is obvious to assume that the bicycle infrastructure directly depends on the density of roads, because most often bicycle paths are laid either in a strip on the roadway or as a separate path parallel to the roadway. The second option is considered the safest [20].

We have compared the statistics of countries those were included in the top most bicycle used countries and Azerbaijan, the corresponding density of roads (road network length relationship to the territory covered area) and population density:

TABLE III. DENSITY OF ROADS AND POPULATION AMONG COUNTRIES WITH HIGHEST POPULARITY OF CYCLING AND IN AZERBAIJAN

Country	The density of roads, m / km2	Population density, pers / km2
Netherlands	3270	404
Denmark	1677	128
Germany	1805	230
Sweden	1288	20
Norway	244	13
Finland	310	16
Japan	3225	336
Switzerland	1696	185
Belgium	5018	341
Azerbaijan	681	115

V. RESULTS

Table 1 shows that the proportion of pollutants emitted by motor vehicles into the atmosphere, in a total amount of pollutants in Azerbaijan reached more than 80% during the past 8 years. The average annual growth rate is about 5%. We can influence this reality by using the data from the resulting equation:

$$P = 59.64 - 12.62 * NB + 1.49 * NC, \quad (1)$$

R-squared 0.895303
Adjusted R-squared 0.857231
Durbin-Watson stat 1.813221

where

P - the percentage of pollutants emitted by vehicles into the atmosphere (in percent);

NB - number of bicycles per 100 households, pcs.;

NC - the number of cars per 100 households, pcs.;

The model can be interpreted as follows: about 4 units of bikes will be required to reduce emissions from cars by 13 percentage points, while the use of bicycles, of course, leads to less use of the car, and this, in turn, directly affects the reduction of air emissions. Separately, a decrease in the number of cars by one unit per 100 households will lead to a

reduction in atmospheric emissions by 1.49 percentage points.

The study of the dependence of life expectancy on the number of bicycles and cars per 100 households and the number of deaths from road accidents for the period from 2005 to 2019 (Table 2) showed the following relationship:

$$LE = 2.39 * NB + 68.69 \quad (2)$$

R-squared	0.883089
Adjusted R-squared	0.870099
Durbin-Watson stat	1.616854

where,

LE - life expectancy, years;

NB - number of bicycles per 100 households, pcs.;

Looking at the model, it can be noted that, increasing the number of bicycles to 5 in every 100 households increases the life expectancy of up to 2,4 years.

In conclusion, in order to compare with the situation in Azerbaijan, we separately analyzed countries with a high rate of cycling development in relation to road density to population density (Table 3), and we obtained the following regression equation:

$$DR = 409.66 + 8.87 * PD, \quad (3)$$

R-squared	0.775024
Adjusted R-squared	0.742885
Durbin-Watson stat	1.863497

where,

DR - densities of automobile roads of countries, m/km²;

PD - population density of countries, pers./km².

With the help of it, we have come to the conclusion that in countries where cycling is very popular an increase in the population by 1 person per sq km will lead to an expansion of the road network by 8.9 meters per sq km. It is easy to determine that today these figures are approximately 5.9 meters per sq km for Azerbaijan.

VI. DISCUSSION

A polluted atmosphere is a slow death for the entire population of the Earth. Technological progress became the originator of such a global problem. Azerbaijan against has also suffered significantly from air pollution. According to the results of regression analysis, we found that increase in the number of bicycles in Azerbaijan by about 1% will reduce in the share of atmospheric emissions by 13 percentage points. And taking into account the fact that the number of plants and factories that also affect the environment in the country has significantly decreased in recent years, it can be assumed that the atmosphere will generally improve.

The last model was aimed at identifying road density standard, depending on the population density in the country. The figures obtained for cyclist countries could be larger, if not Norway and Finland, countries with a large share of the territory unsuitable for living in connection with the cold climate. Yet, the immediate result gives cause for reflection.

VII. CONCLUSION

Bicycling will lead to a social results - people's behavior and attitude to each other will change, being human capital, their physical and mental endurance will improve and thereby will bring longer economic benefits for the country. This

process may eventually qualitatively change society for the better.

Azerbaijan, a country that seeks to redirect the dependence of sustainable economic development from the oil sector to other sectors, in particular tourism, should already have to take measures to join the project of a single bicycle road. There are a number of issues that must first be solved. The main problem is that the road infrastructure condition of which, taking into account the population, today is significantly inferior to the road network of bicycle countries. The main advantage of the density of the road network is a significant increase in bicycle mobility, which is so important during peak hours. In order to introduce such changes in roads, an initial boost to the mass transfer of population from cars to bicycles, which can result in the following activities:

1. Subsidizing the production and sale of bicycles;
2. The development of safe bicycle infrastructure in the existing road network with priority of laying a separate bike path from the roadway;
3. An increase in bicycle rental stations with an aim of increasing the rate of (or popularize) bicycle sharing (Bike Sharing);
4. The establishment of special parking spaces for bicycles along with parking spaces for cars.

In addition all above mentioned points, it must be pointed out that people will only ride bicycles when riding them becomes a safe option. As full-fledged road users, they should be informed about the rules, receive a fine in case of non-compliance, and sometimes have advantages on the roads.

Our results on the example of Azerbaijan can be used for further research in this area and have practical significance for the representatives of state executive bodies, the private sector, as well as interested parties in this area.

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