

# Transport System and Competition

Říha Z., Jírová V., Faifrová V.

**Abstract**—The division of labour in the transport system, or allocation of transport capacity among different modes of transport, is one of the key issues at hand and it is important to deal with it. Generally, it is mainly a question of what affects the division of labour. As already shown in the first chapter in the historical research, the technological development in the last 200 years in Europe contradicted mainly the road and rail transport. Fast acceleration of railways in the second half of 19<sup>th</sup> century and the development of road transport in the 20<sup>th</sup> century enabled business to develop in many new parts of the world on the one hand. On the other hand, it raised questions of the impact the transport system made on the environment (externalities).

**Keywords**—Transport System, Externalities, Competition, Cross elasticity, Demand

## I. INTRODUCTION

**T**RANSPORT (or trade) in the history of mankind identified not only the position of a city but also their inner form and it was not only essential an element of economic development, but also a prerequisite for exchange of goods. If you are concerned exclusively with history, we can state the following facts [1]:

- relationship between transport and economic development is known and proven since ancient times;
- development of transport routes was in antiquity and the Middle ages motivated primarily by military and commercial purposes;
- in the Middle ages countries on the Mediterranean coast dominated – logically, they had the best approach to mutual trade;
- trade boomed thanks to two types of commodities, the first group consisted of regionally scarce goods (salt, minerals), the second group then of luxury goods such as amber or silk; demanded goods of the Middle Ages were slaves;

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- transport has always had a strong energetic and environmental dimension – that is intensified in the 19<sup>th</sup> century in the beginning of the Industrial Revolution;
- 19<sup>th</sup> century also marked the beginning of „modern cities“, where life began to accumulate (people migrated to cities for work) and demand for new forms of urban transport was created;
- establishment of rail transport had more meanings – two basic aspects are:

- ✓ to eliminate the monopoly of various kinds of water transport (in general, the most effective way to remove monopolies is technological development);
- ✓ a railroad allowed to build infrastructure independent of the natural dispositions and thus to engage in trading countries which had no sufficient access to the sea and rivers;

- the importance of transport grew with the industrial revolution due to division of labour;
- the use of oil for propulsion of vehicles had fatal consequences for the development of transport and society, in a mass scale it took place in the 19<sup>th</sup> and 20<sup>th</sup> century;
- development of individual transport significantly affects lives of people, especially in urban areas it had a major impact on the environment.

History research is not an end in itself but it is rather beneficial in many ways. It can be said that a lot of exciting events and interaction are hidden in human history and we can get a better understanding of the present by learning and decoding them. With regard to transport, the key moment in terms of today was the beginning of the use of oil to drive vehicles at the turn of 19<sup>th</sup> and 20<sup>th</sup> century. 20<sup>th</sup> century benefited on the cheap oil until the beginning of 1970s when the first crisis took place. In the early days of motoring people praised the loss of horse manure in the streets, later hand in hand with the acceleration of individual transport they began to recognize and address the issue of air pollution, noise and congestion in cities.

At the same time the transformation of medieval cities (mostly not build for vehicular traffic) meant an expansion and gradual population growth, which of course led to environmental problems. If traffic originated in history especially for commercial reasons, i.e. in order to exchange goods in a long distance, in the last two centuries traffic has gradually become a means to make passenger traffic easier.

Also cargo transport underwent great progress. Before the industrial revolution especially perishable commodities (goods) were transported, which were not locally available (salt, copper, luxury goods, etc.), today goods of everyday consumption is transported at a great distance. Issues that are being solved in transport today (and are mutually linked) obviously stem from history and are mainly not new:

- issue of labour division in transport and transport performances of individual types of transport;
- relationship of transport and environment in accordance with the theory of externalities;
- energetics of transport systems, their sustainability in a current form with respect to price development on the market with energetic raw materials and to the state of supply of classical energetic raw materials;
- quality of individual types of transport, more precisely quality of life, especially in urban agglomerations and its impact of transport systems.

The role of transport in the 21<sup>st</sup> century will be different, it is indicated in chapter 1 of this dissertation, and the question is, in what form we will continue to use the service. The tendency in recent decades (particularly automobile traffic acceleration) indicate that it will be necessary to solve traffic problems especially in the cities that are struggling with a lack of space, and then also the problem of energy sources for transportation (or other source of compensation for oil), whatever reasons there are – environmental (reducing emissions from transport), strategic (in particular connected with security of supply of oil and gas from these countries possessing raw materials) or other (mainly discussed oil depletion over the next 50 to 100 years).

At the turn of the 19<sup>th</sup> and 20<sup>th</sup> century urban transport developed incredibly idyllically – public transport was gradually established with no serious competitor until the 20<sup>th</sup> century when it became motoring. European cities (Prague is an excellent example) began to experience a lack of space because their centres were not designed for this type of transport.

To make the public and vehicular transport competitive it will be necessary to put emphasis on its quality in the coming decades. Quality criteria include availability, accessibility, information, journey time, customer care, comfort, safety and environmental impact. If appropriate measures will be gradually achieved by extruding individual transport from city centres (by economic instruments, such as tolls), it must be replaced by quality public transport in these indicators. It is connected with searching for financial recourses because higher quality means additional costs (for example at the turn of the 20<sup>th</sup> and 21<sup>st</sup> century many transport companies switched to low-floor buses, which are costly in terms of investment and operation).

Transport of the 21<sup>st</sup> century will have to deal with more serious problem and it is connected with searching for transport of energy resources. It is obviously a problem old as

humanity itself which was solved (probably only temporarily) during the peak of the industrial revolution when oil became an ideal product for vehicles. Though oil, known for hundreds of years, has never been a popular source of energy. Mankind has used it in many different ways – in civil engineering, in ancient Rome as a remedy for indigestion. In the 19<sup>th</sup> century oil replaced whale oil and at the turn of the 19<sup>th</sup> and 20<sup>th</sup> century oil was used as a source for propulsion of cars. This natural source became a source of economy, mankind knew about oil for a long time, but due to technological development that enabled to use oil massively. In this context we can ask whether we are in a similar situation and we find a new energy source for the future, perhaps yet unknown technology will enable to use what we now have before our eyes but we don't see it.

There are possible alternatives of oil but there are not competitive enough. We have four basic requirements – i.e. technological, energetic, ecological and economic comparability with common fuel. From the technological point of view not only means of transport are concerned but also building infrastructure of stations (in the case of charging electromobility). Another problem is energetic characteristics – the proportion of generated and inserted energy. This proportion is the most favourable for the energy resources that have essential advantage – they can offer a large amount of energy in a small volume of material. This indicator was the best in the beginning of its use but it gradually declines with deteriorating conditions of oil mining.

The energy point of view has its other dimension, it is necessary to produce and „subsequently transfer“ the energy into vehicles. There is no sufficient energy source or the necessary infrastructure. It is shown on the example of hydrogen which is only a transport medium (thus medium which is only a transport medium for energy which must be produced), not its source [2].

Generally, the transport system is described as a system which is composed of three basic elements:

- transport and technology used,
- transport infrastructure,
- management and information systems,

First of all, new technologies and new opportunities in the field of information systems help to provide transportation system with much greater quality and introduce elements that were unimaginable not long ago, whether in terms of competition within the rail, toll infrastructure or different information systems (see also [3]). The function of the transport system can be divided into five areas:

- national economy – trade can greatly contribute to the growth of GDP;
- environmental – associated primarily with production of externalities;
- energetic;
- urban – or city-forming;

- strategic (eg. in terms of defence).

In a specific national economic of the transport system transport has a major impact on economic growth, that results from the following causes:

- transport supports higher employment (production of means of transport, construction, maintenance, and reconstruction of transport infrastructure, petrochemical industry and links to other business activities, transport companies);
- promotion of trade, both at the local level – municipal, regional – and global, ie. national and international level;
- a significant contribution to the state budget (the tax system and a wide range of taxes).

Transport means purposeful process of change of means of transport after transport route for transfer of persons, animals or things. It is ranked among the network industries, ie. it uses infrastructure for its existence. The reason for the emergence and existence of transport is demand after relocation (transport), which is connected with disagreement and fulfilment of human needs (work, school, entertainment, etc., ie. passenger transport) and discrepancy between the place of mining, processing, production and final consumption (ie. freight transport). In this sense the demand for transport is a derived demand, ie. it is determined by processes outside traffic [4].

State transport system consists of a complex system that has a relationship to the environment, it is internally structured, and between subsystems and a system and a system and environment there are numerous interactive relationships, context and processes. It is a dynamic system with the target behaviour in which the determining element is a person acting in a certain situation as an individual, in another as a team member, and if necessary as a member of a higher community. For a better understanding of traffic it is good to define its features to other (production and non-manufacturing) fields of human activity. Such features are:

- transport product is immediately consumed at the same time of its origin, i.e. it is not storable; temporal and spatial uniformity of requirements of transport cannot be balanced by reserves in capacities that are unused over a certain part of the year;
- transport and traffic are carried on in large areas; the aim is to ensure that all regions have a comparable level of transport service. This requirement emphasizes non-economic aspects in the transport system and its result is an increase in demand for financial resources;
- the transport process is continuous in time and it is batch processing, i.e. relocation takes place in batches whose size is limited by capacity of a transport unit and it is determined by factors outside traffic;
- transport is a dynamic process that can be determined by a vector and quantity, direction, distance and time;

- passenger transport is a network industry where most participants are able to provide the required power (ie. transport) alone (especially in passenger transport which leads to the formation and existence of individual automobile transport – IAT); changes in lifestyle reflect demands for transport and its quality;
- transport has a strong impact on the environment – mainly due to their high performance; it is also due to the inefficient use of existing capacity (high share of road transport, passenger transport IAT);
- the role of quality of transport – transport is a service where quality plays a major role in allocation of performance (or demand) among its different kinds; price is also an important criterion, however, both in passenger and freight transport will still depend on other less quantifiable factors;
- transport system is specific in division of transport labour among various transport modes which is due to technological differences very difficult to create comparable conditions for economic competition and in some cases even within a single mode of transport.

## II. ELASTICITY OF TRANSPORT DEMAND

It is necessary to make the following remarks on the issue of the division of labour:

- types of transport compete with each other but they cooperate at the same time;
- different types of transport originated in different historical periods;
- types of transport have significantly different technologies consequently also different qualitative parameters;
- in addition to prices there will also be qualitative indicators and the nature of transport as important factors ;
- we can legitimately ask a question on the competition among different types of transport in terms of their mutual substitutability;

Generally, for perfect competition, the following conditions must be met[5]:

- complete awareness of buyers and sellers;
- zero switching costs;
- homogeneous product;
- large number of bidders (sellers).

The transport market will have significant limitations in this regard. It will be all about particular products, thus different types of transport, not a homogeneous market; in other words the product of road transport will have different qualitative parameters from the rail or air transport. There will be inhomogeneity also in competition within a single mode of transport, especially with regard to time of the mutually competing transport connections. For a passenger, or more precisely a carrier, it does not have to be quality or price that plays the major role in the selection of a connection, but

departure time, or arrival time (in general we can say that it is the nature of transport which will determine the selection of the carrier).

A large number of bidders is problematic. The bidders are limited by three factors. First, the technical and technological barriers associated primarily with limited infrastructure capacity. Second, financial barriers and the need for high capital expenditure at the beginning of business. Third, the legislative factor which includes particular legal requirements for obtaining authorization to do business in the field of transport. These natural barriers will again determine the market and emergence of effective competition.

The market needs a sufficiently elastic supply and demand for its functionality. Demand for transport is a derived demand, i.e. transport is always derived from the need to transfer and is not so much tied to price movement. At the same time, the demand of carriage is unevenly distributed in time which also causes problems with little use of capacity transport. And finally – to achieve elastic supply, transport products must be storable (an offer is elastic if the offering party is able to deliver a product on the market at the time of its price increase), which is a requirement that is not met. Moreover, the additional supply is bound to a further increase of the required capacity of vehicles which can run into the aforementioned economic barriers.

The consequence of such conditions as the market approaches perfection (into the so-called monopolistic competition), it is a bidder (entrepreneur) who is able to influence the price. In the environment of perfect competition, if a bidder will be a recipient of a particular price, then the demand curve will be perfectly elastic – that is, he will not be able control the final price (which will be an intersection of supply and demand curves). In imperfect competition it is possible to influence a higher price if a local seller increases the price; it does not have to mean a reduction in demand in case of non-zero switching costs (a demander deducts these costs into their final price).

The following image clearly shows the above mentioned [6]:

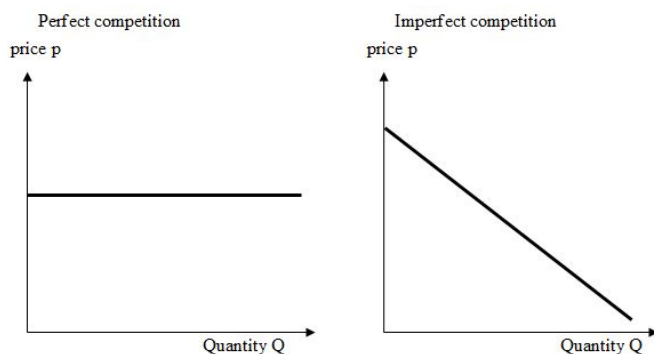


Fig. 1 – Perfect and Imperfect Competition

Another condition of the perfect market is a homogeneous product, i.e. all bidders will supply a product of the same structure or features – in practice the condition can be obviously met only in a limited number of cases, such as

market of primary raw materials or grain. It is interesting to analyse if products which should compete on the market are substitutes. This topic is linked to the so-called cross elasticity.

Generally, the elasticity of demand  $e_d$  shows the relationship between price  $p$  and demanding quantity  $Q$  after a certain product. In case of a good, we express elasticity by relationship:

$$e_d = \frac{\frac{\partial Q}{Q}}{\frac{\partial p}{p}} \quad (1)$$

We say that demand is elastic in the base when elasticity is bigger than one, i.e. even a very small change in price causes a large change in demand for a good. On the contrary, when a large change in price causes a small change in quantity demanded (which happens mainly with hardly substitutable goods that do not have an adequate substitute), we talk about inelastic demand (elasticity in these cases is less than one).

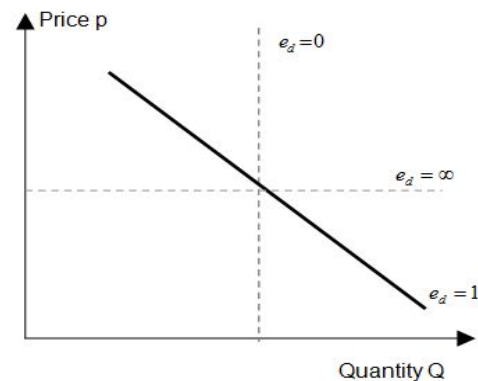


Fig 2: Elasticity of Demand

When we talk about so-called cross elasticity, two goods A and B are compared which are either substitutes (ie. mutually replaceable goods), complements or complementary goods or they have no similar relationship. Cross elasticity is expressed in the following relation [4]:

$$e_{d,A,B} = \frac{\frac{\partial Q_A}{Q_A}}{\frac{\partial p_B}{p_B}} = \frac{\partial Q_A \cdot p_B}{\partial p_B \cdot Q_A}, \quad (2)$$

where  $Q_A$  is the demand for good A and  $p_B$  is the price of good B. The object of study is the change in the demand for the good A with a unit price of the good B. Whether the goods A and B substitutes or complements can be expressed by the following image. The important prerequisite is a permanent price of the good A.

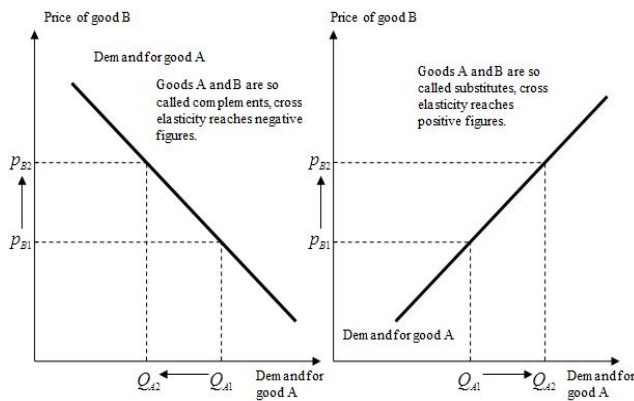


Fig. 3: Principle of cross elasticity

To be able to assess through the example of cross elasticity whether the various modes of transport are substitutes, one must first describe the development of prices thoroughly, more precisely the price development of oil. Its unbalance in the recent period started in 2007 provides a useful way to analyse whether the increasing costs of the transport modes, for which oil is the primary source of energy [7], lead to an increase of transport capacity in public transport.

III. CROSS ELASTICITY AND ALLOCATION OF WORK IN TRANSPORT

We can therefore apply the principle of the economic elasticity to explain the influence of the price on the allocation of work. As an example the relation between passenger automobile transport and passenger train transport can be used where the quarterly index of the transport operation over the past decade in the Czech Republic can be applied. The procedure according to the specific relation which is based on (2):

$$e_{d,IAD,ZD} = \frac{Q_{ZDt} - Q_{ZD(t-1)}}{Q_{ZDt} + Q_{ZD(t-1)}} \div \frac{P_{IADt} - P_{IAD(t-1)}}{P_{IADt} + P_{IAD(t-1)}} \tag{3}$$

where:

- $e_{d,IAD,ZD}$  ... cross elasticity of the railway transport demand in accordance with the fuel prices
- $Q_{ZDt}$  ... volume of passenger railway transport over period t
- $Q_{ZD(t-1)}$  ... volume of passenger railway transport over period t-1
- $P_{IADt}$  ... individual car transport price over period t (represented by the average fuel price)
- $P_{IAD(t-1)}$  ... Individual car transport price over period t-1 (represented by the average fuel price)

The price of passenger transport is intended to be represented by the fuel price assuming the supposition that the fuel price is the core part of perceived costs, other costs (purchase of the car, annual costs etc.) belong to sunk costs spent in the past and our decision making about the choice of the means of transport do not themselves influence the route.

The analysed period refers to 2002 - 2012 when (see [8]) significant turns in fuel prices were observed.

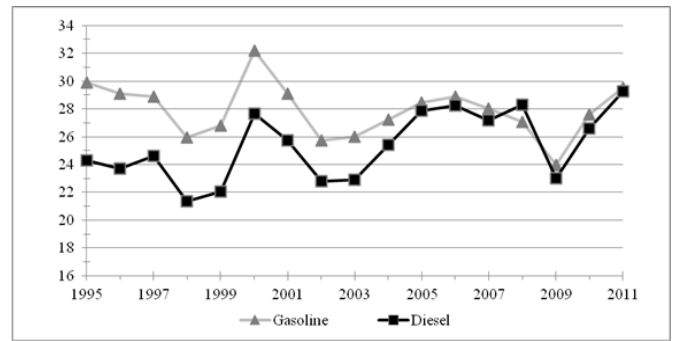


Fig. 4: Fuel Price Development in the Czech Republic (CZK/l) [9]

According to available data, a quarter of a year is the shortest period for which the results are summarized in the following stacked bar chart.

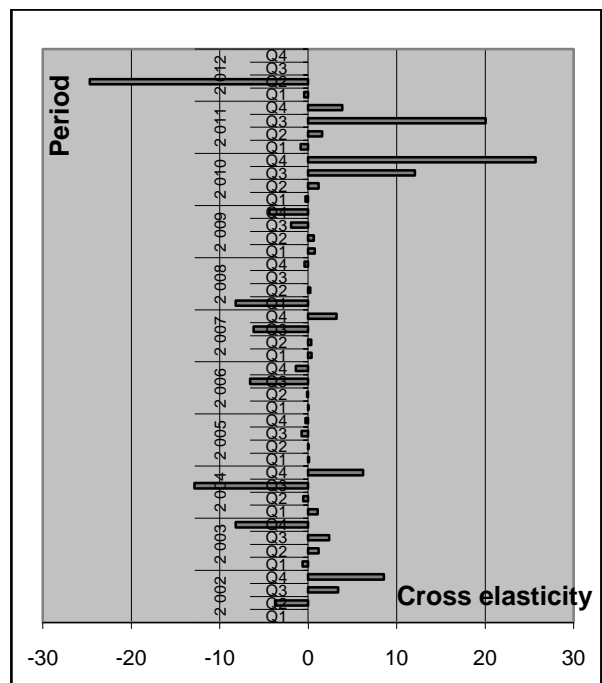


Fig 5: Cross elasticity figures for passenger automobile and railway transport

How these results can be most fully presented is the question indeed. According to the standardized economic theory, it can be said that the figures are of variable character which refer neither to substitutes no to complements. Unless we know what types of goods are referred to, we would presumably come to the conclusion that they are not related at all.

Another interpretation might claim that in a specific period of time and with a specific fuel price interval, the demand is not transferred from the individual onto the railway transport. Another conclusion might be that despite the resulting effect of both goods - i. e. transport - is the same, not referring to substitutes as they are of different quality and quantity parameters.

IV. FURTHER REMARKS ON ALLOCATION OF WORK IN TRANSPORT

Before expressing further conclusions concerning the allocation of work in the transport system, it is vital to complement in-depth statistics, bearing in mind the decline or stagnation of operation within the transport system of Eastern and Central Europe over the past two decades.

Various causes of such conditions can be observed - the change of the standard of living to be named among the many, along with higher car availability, or the emphasis on the higher mobility of the population. In comparison to other countries, it is highly interesting that the railway transport is on a long-term rise, especially in the index of the operation in transport per person (pkm/person). Among such countries Germany, France, and Great Britain can be listed [10].

The countries vary in their current conditions. In countries where the operation in railway transport rises, motorization (i.e. number of cars per 1,000 inhabitants) stagnates or inclines slowly. On the contrary in the countries of the former Eastern Block, this index has risen significantly over the past two decades which could be observed by the decline in the operation in the railway transport.

The percentage rise in motorization between 1991 and 2009 is exemplifying. Baltic countries reached the highest figures, on the other hand the standard capitalist countries only reach figures below 50%:

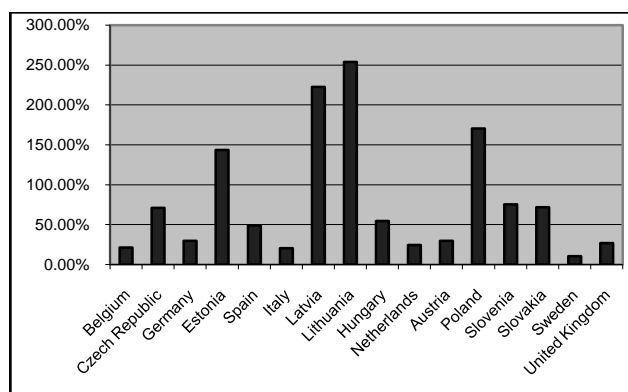


Fig 6: The increase in motorization in the selected European countries [11]

This graph that can be complemented by the growth of motorization clearly shows that in the richer countries the motorization growth gradually declines to the 1 figure. We can assume that such countries show the exchange of the vehicles rather than the overall growth which might explain why in the richer countries the inclination to railway transport is more predictable. The economic study suggests that the key factors which influence customers in the choice of product are the price and the quality in transport, though, these factors are determined by the characteristics of the transport i.e. the set of characteristics which the specific operation possesses. Among these we can name the time of departure and arrival, as well as the route or the kind of product in freight transport. In

passenger transport, the elementary factors which influence the allocation of work can be summarized as follows:

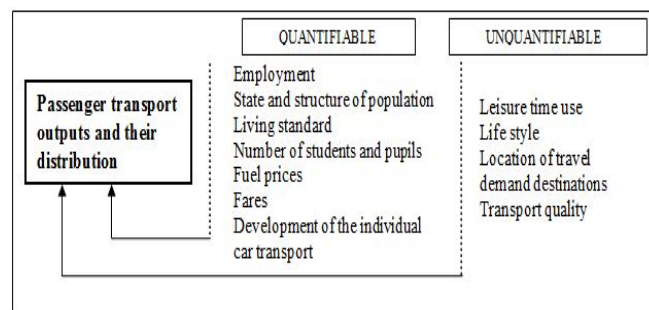


Fig. 7 The factors affecting the allocation of work in passenger transport

V. CONCLUSIONS

Passenger transport offers much higher quality parameters (speed, availability, comfort etc.) than public transport as well as higher costs. The preference of car transport can be explained by the passenger being willing to pay more for higher quality - in other words the difference in costs of individual and public transport refers to the higher quality.

The demand of individual transport is non-elastic as the inclination of the passengers might come along with certain economic changes (drop in GDP and decline in lifestyle, sudden rapid growth in fuel prices) - not speaking of the legislative intervention into the free choice of the means of transport, standard of living also leads to a higher mobility demand within the population hand in hand with the focus on individual transport which can fulfill such demands.

Statistics also show that the incline in standard of living is not equal to the growth in motorisation, the index figure begins to stagnate at the rate of two people per a car.

On the allocation of work between individual means of transport and their additional indexes (unemployment, age range, or the position of the desired locations). This is demonstrated in the figure 8 which shows the energy consumption and the density of population. The higher the density is the lower the electricity consumption unit is i.e. individual locations are more easily reachable [12,13].

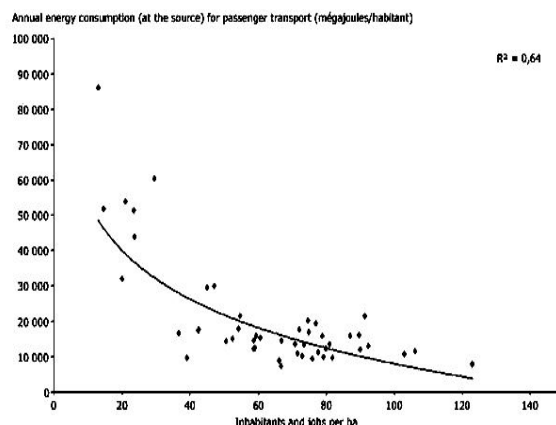


Fig 8: Relation between the density and energy consumption unit in transport [12]



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