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Impact of Transport Infrastructure Investment on Economic Development and Employment

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Abstract: The present paper is an effort to support a rational and justified answer to the question whether and to which extent the various categories of transport infrastructure (airports, roads, railways, ports) contribute to economic development and employment. The analysis is based on a review of relevant scientific work and research conducted by the authors. Conditions for a transport infrastructure to contribute positively to economic development are first analyzed: location of investment, nature of goods and services produced, eventual comparative advantages, conditions of the market, political and economic environment. Difficulties in establishing an analytical relationship relating economic developing and its generating factors (labor, capital and infrastructure) are identified and discussed. A disaggregated approach concerning effects on GDP of each type of transport infrastructure is then addressed. From data from airports all over the world it is established a clear causal relationship between the number of passengers of an airport and direct and indirect/induced jobs created form the activity of the airport. Similarly, causal relationships between amounts invested in road and rail infrastructure and growth of economic activity and employment is depicted.

Keywords: Transport infrastructure, Economic development, Job creation, Modeling, Airports, Ports, Railways, Roads.

1. Is Transport Leading to Economic Development?

The relationship between transport infrastructure and economic development is complex and extremely controversial. Contrary to what is thought usually, new transport infrastructure does not lead for sure and immediately to economic development, i.e. to the increase of economic output either to national or regional level [1,2]. Indeed a new motorway or high-speed railway or airport improve accessibility and thus give the possibility for regional products or services to have access to more central markets. However, at the same time these products and services may face a hard competition, as they loose their former monopolistic nature. The balance between transport infrastructure and economic development is indeed positive if a competitive advantage for regional products and services arises as a result of new investment. Otherwise, it may be negative [3,4].

Figs. 1 and 2 illustrate a flowchart of the interaction between transport improvements and economic development and labour market, whereas Fig. 3 classifies effects of infrastructure investments in direct (those resulting from changes in accessibility) and indirect ones. In Fig. 4. are illustrated major results of our analysis concerning the existence or not of a causal relationship between rail, road and air transport on the one side and GDP on the other.

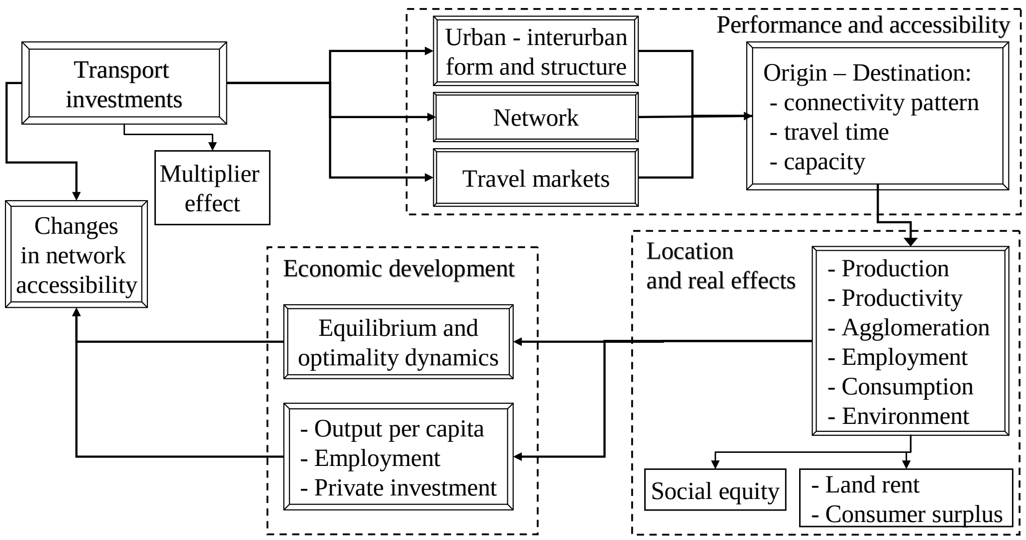

Figure 1. The causal relationship between transport investments and economic development [5].

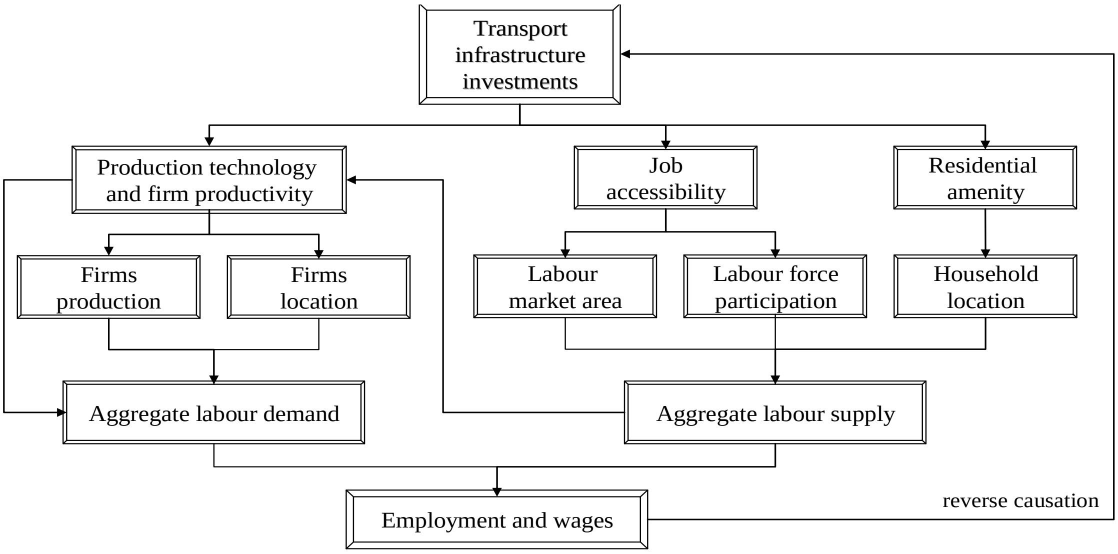

Figure 2. The causal relationship between transport infrastructure investments and labour market [6].

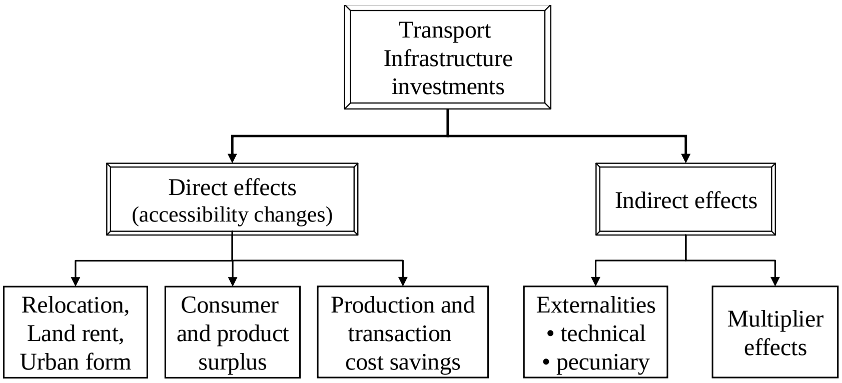

Figure 3. Classification of transportation infrastructure investments [7].

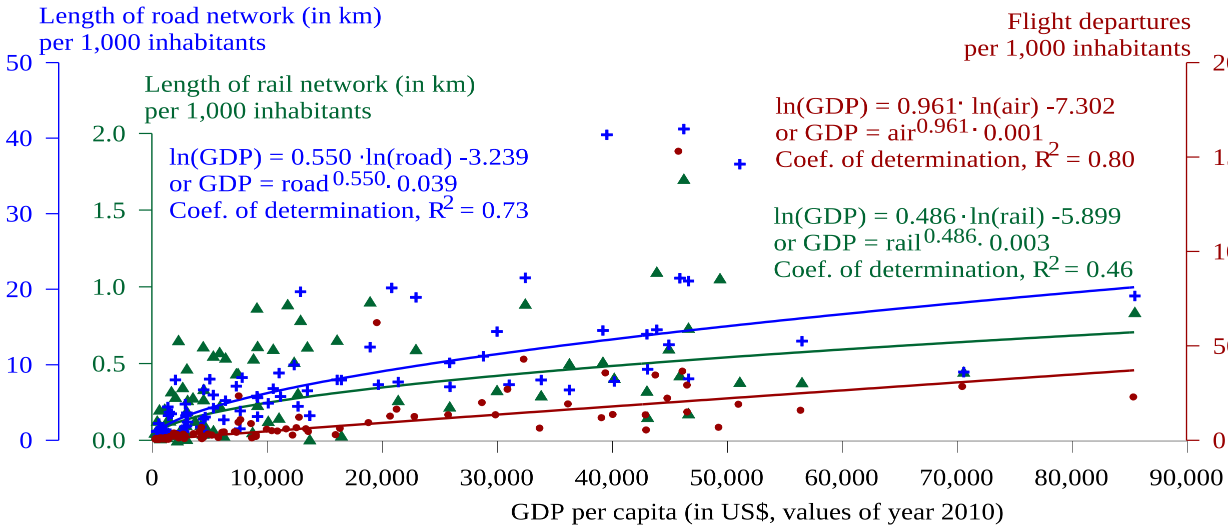

Figure 4. Survey whether a causal relationship exist between road, rail and air transport and GDP (data of 96 countries worlwide, compiled by the authors).

2. The General Functional Relationship between Transport and Economic Development

It is accepted that the economic output is a function of capital investments, of the level of human resources-productivity and of available infrastructure (transport, telecommunications, etc.). Referred to as equation of Cobb-Douglas this relationship takes the form:

$$Y\,(L,C,I) = a\cdot L^{b}\cdot C^{c}\cdot I^{i} \qquad (1)$$

where Y represents the total production (the monetary value of all goods produced in a year), L is the labour input (the total number of person-hours worked in a year), C is the capital input (the monetary worth of all machinery, equipment and buildings), I represents the transport and telecommunication infrastructure (the monetary worth of all machinery, equipment and buildings), a is the total factor productivity and b, c, i are the output elasticities of labor, capital and infrastructure, respectively. These values are constants determined by available technology.

The difficulties to devise an analytical form of (1) have led to a series of analytical studies, which try to assess in a more or less empirical way the economic effects of specific transportation projects. Such analyses and new research findings are presented below.

3. Transport Investment Economic Impact

3.1 Short-term economic impact

Capital investment in public transportation is a significant source of jobs. In the United States nearly 23,800 jobs and in the European Union (of 15 countries + Norway + Switzerland) nearly 13,150 jobs are (directly and indirectly) supported for a year, per billion US$ (or € respectively), of spending on public transportation capital investments (including purchases of vehicles and equipment, and the development of infrastructure and supporting facilities). As far as transportation operations investments are concerned, in the United States over 41,000 jobs and in the EU (of 15 countries + Norway + Switzerland) nearly 22,000 jobs are (directly and indirectly) supported for a year, for each billion US$ (or € respectively) of annual spending on public transportation operations. Tables I and II illustrate a breakdown of these jobs, distinguishing categories of direct effects (public transportation manufacturing /construction and operations jobs), indirect effects (jobs at suppliers of parts and services) and induced jobs (jobs supported by employees re-spending their wages). Besides the creation of new jobs, transport investments have and other significant economic effects. New jobs lead to added business output, which ensure the creation of added value (interpreted as increase of GDP), whereas the additional economic activity generates federal and local tax revenues, (Table II).

TABLE I. SHORT-TERM ECONOMIC EFFECT PER BILLION € OF NATIONAL TRANSPORT INVESTMENTS IN THE EU-17 (15 EUROPEAN UNION COUNTRIES[a] + NORWAY + SWITZERLAND), (DIRECTED AND INDIRECTED/INDUCED EFFECTS)

Economic impact of transport investments	Capital investments	Operations investments	Both capital and operations investments	
			29% capital and 71% operations	31% capital and 69% operations
New jobs (in thousands job × years)	13.15	21.87	19.35	16.08
- direct effect	5.89	15.22	12.49	10.41
- indirected effect	5.10	1.87	2.84	2.33
- induced effect	2.16	4.77	4.02	3.34

a. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.

TABLE II. SHORT-TERM ECONOMIC EFFECT PER BILLION US$ OF NATIONAL TRANSPORT INVESTMENTS IN THE USA, (DIRECTED AND INDIRECTED/INDUCED EFFECTS), [8].

Economic impact of transport investments	Capital investments	Operations investments	Both capital and operations investments	
			29% capital and 71% operations[b]	31% capital and 69% operations
New jobs (in thousands job × years)	23.80	41.10	36.10	30.00
- direct effect	8.20	21.20	17.40	14.50
- indirected effect	7.90	2.90	4.40	3.60
- induced effect	7.70	17.00	14.30	11.90
Labor income (billion US$)	3.00	3.80	3.60	3.00
Business sales (billion US$)	1.50	2.00	1.80	1.50
GDP (value added, billion US$)	1.10	1.80	1.60	1.35
Tax revenues (billion US$)	0.35	0.53	0.49	0.41

b. Average national investment mix in the USA [8].

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3.2 Long-term economic impact

The potential long-term economic effect of transport investments is based on [8]:

– reduced traffic congestion, leading to further direct travel cost savings for businesses and households,

– travel and vehicle ownership cost savings for public transportation passengers and those switching from automobiles, leading to shifts in consumer spending,

– business productivity gained from access to broader labor markets with more diverse skills, enabled by reduced traffic congestion and expanded transit service areas,

– business operating cost savings associated with worker wage and reliability effects of reduced congestion,

– additional regional business growth enabled by indirect impacts of business growth on supplies and induced impacts on spending of worker wages.

One billion of US$ annual public transportation investment leads, in the United States, after a 20 years period, to more than $1.7 billion of net annual additional GDP due to cost savings and to $1.8 billion of GDP supported by the pattern of public transportation spending. Thus, the total long-term impact can be $3.5 billion of GDP generated per year and per billion of investment in public transportation [8].

3.3 Job generation impact of transport investment

During a period of a worldwide financial and economic crisis, the job generation impacts of transportation investment are particularly valuable. Thus, it is useful to examine the types of jobs that are generated directly or indirectly by spending on transportation capital and operations. The job impacts of transport investments can be examined in two distinct ways [9]:

♦ Directly effected: They refer to jobs related with constructing transportation systems (vehicles, facilities, etc.), as well as to jobs related with operating and maintaining them. These “direct effects” jobs are further classified in four categories, (Fig. 5):

  – blue collar semi-skilled jobs (drivers, ticket agents, construction, etc.),

  – blue collar skilled jobs (manufacturing, service and repair workers, etc.),

  – white collar semi-skilled jobs (clerical jobs),

  – white collar skilled jobs (managerial workers, technical engineers, etc.).

♦ Indirectly effected: They refer to a wider range of jobs generated by suppliers of goods and services benefiting from workers re-spending their wages. These “indirect effects” jobs are also classified into four categories, (Fig. 5):

  – blue collar semi-skilled jobs (grounds keeping and personal care workers, as well as construction workers and transport workers, etc.),

  – blue collar skilled jobs (manufacturing, service and repair workers, etc.),

  – white collar semi-skilled jobs (retail and wholesale stocking workers, clerical workers, etc.),

  – white collar skilled jobs (legal, banking, technical, managerial workers, etc.).

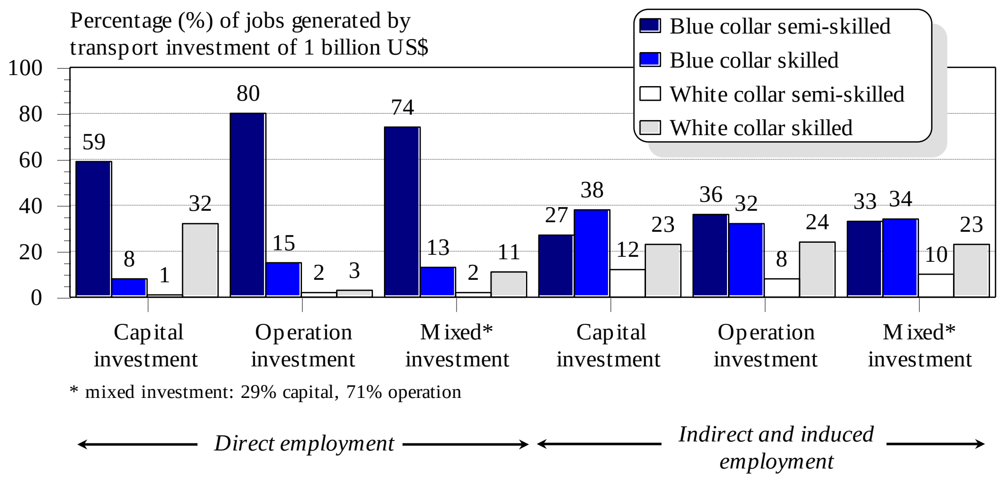

Figure 5. Direct and indirect/induced effects concerning job generation from transport investment [9].

4. Some Evidence of Economic Effects in Relation to the Type of Infrastructure

4.1 Airports

The air transportation system is defined by its infrastructure capability (airports), regulatory or liberalized framework and airline capabilities. Internal to the air transportation system is the supply and demand relationship where airlines provide supply through pricing and scheduling of flights based on the revenues and profitability of a particular route. Airports affect an economy by providing employment in the aviation sector and creating wider socioeconomic benefits through their potential to enable certain types of activities in a local economy because of its distinctive characteristics: speed, cost, flexibility, reliability and safety. The region's economic activity in turn provides capital and generates the need for passenger travel and freight which drives the demand for air transportation services, (Fig. 6).

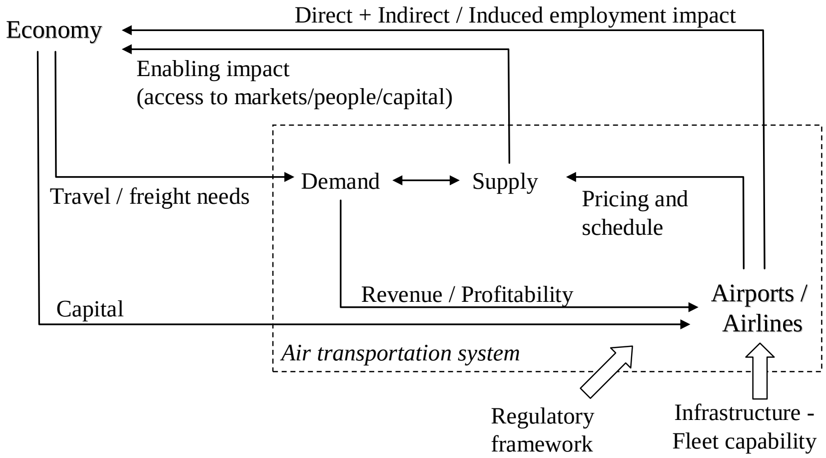

Figure 6. The air transportation system and the economy [10].

Airports support employment directly on-site and in the surrounding area (directed jobs), but also in the chain of suppliers providing goods and services (indirected jobs). In addition, the incomes earned in these direct and indirect activities generate demand for goods and services in the economy, which provoke further employment (induce jobs).

European airports currently support, on average, around 950 directed (on-site) jobs per million passengers (workload units) per annum, (Fig. 7). This is lower than the number observed in the end of the last decade (the 'typical' 1,000 jobs per million passengers ratio), indicating the success of measures taken by airports to reduce costs and increase productivity, despite increases in security measures. Other factors include the development of no-frills carriers and the drive towards lower costs throughout the industry, particularly in the airline sector, resulting in productivity improvements across the board, (see Fig. 1). Nearly two-thirds (64%) of employment comes from airlines, handling agents and aircraft maintenance, with the remainder split between airport operators (14%), in-flight catering, restaurants and retailing (12%), air traffic control and control agencies (6%), freight (1%) and other activities such as fuel companies and ground transport operators (3%) [11]. Concerning indirect/induced jobs, every million of airports passengers support 2,000 indirect/induced jobs nationally, 1,050 indirect/induced jobs regionally or 475 indirect/induced jobs locally, (Fig. 8).

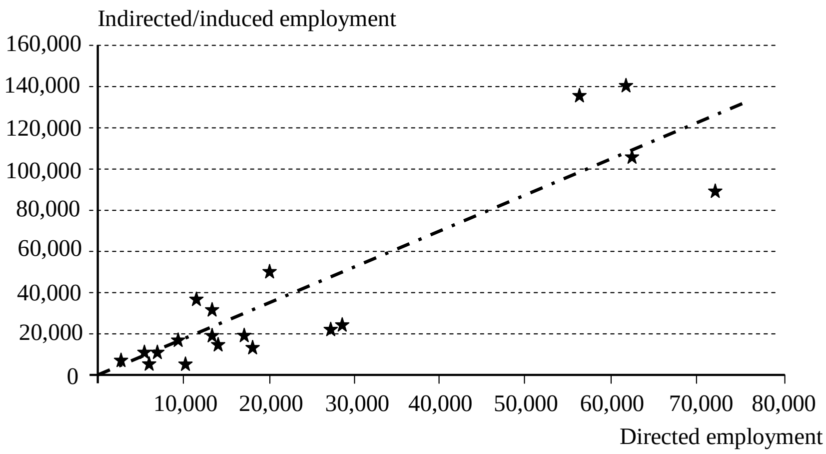

Figure 7. Relationship between directed and indirected/induced employment on European airports [11].

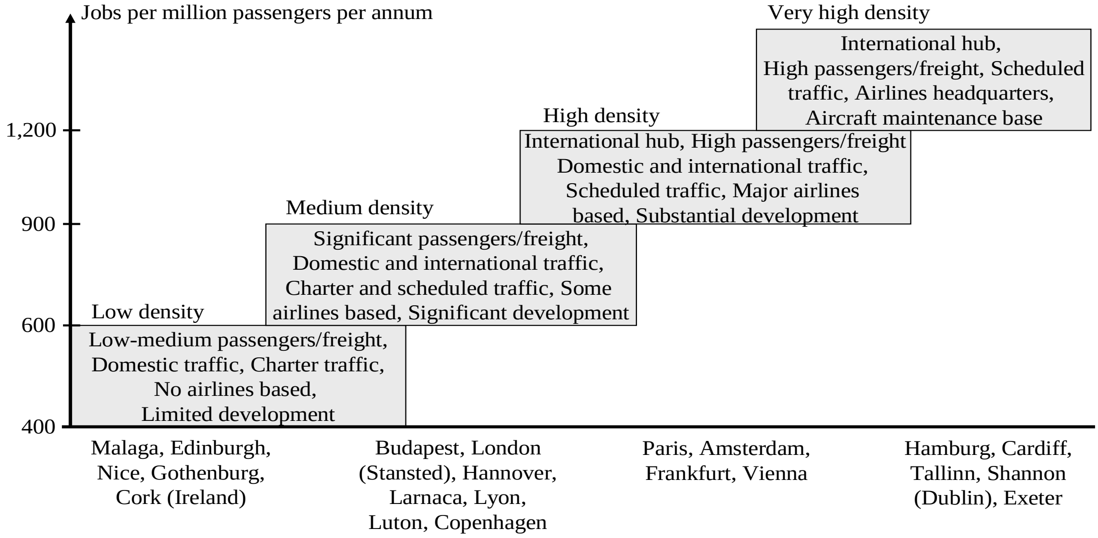

Figure 8. On-site employment on European Airports [11].

In Canada, the 20 busiest airports (with annual passenger traffic of 99.3 million passengers in 2008) supported directly 113,040 jobs (1,139 jobs per million of passenger traffic) and indirectly 186,960 jobs (1,883 jobs per million of passenger traffic). In the United States, 496 airports (with annual passenger traffic of 1,445.67 million passengers in 2010) supported directly 1,316,670 jobs (911 jobs per million of passenger traffic) and indirectly 3,170,510 jobs (2,193 jobs per million of passenger traffic) [12].

In Figs. 9, 10 and 11 we tried to testify whether a correlation between the total annual passenger demand of an airport and both direct and indirected/induced jobs can be established. The abscissa of Figs. 9 and 10 represents the total passenger demand of all airports per State of the USA, while the ordinate represents the direct (or indirect/induced) jobs at State level, derived from data of Federal Aviation Administration [13]. We should outline that in Figs. 7 and 9 (right) the entrepreneurial activity induced from tourism, resulting from airport operation, is not taken into account.

After an extensive analysis based on 35 American, European, Canadian and Australian international and regional airports[1] concerning the annual passenger demand and the related, with the air industry, jobs, we tried an aggregate approach on correlation between the airport passenger demand and direct effects on job creation, (Fig. 10).

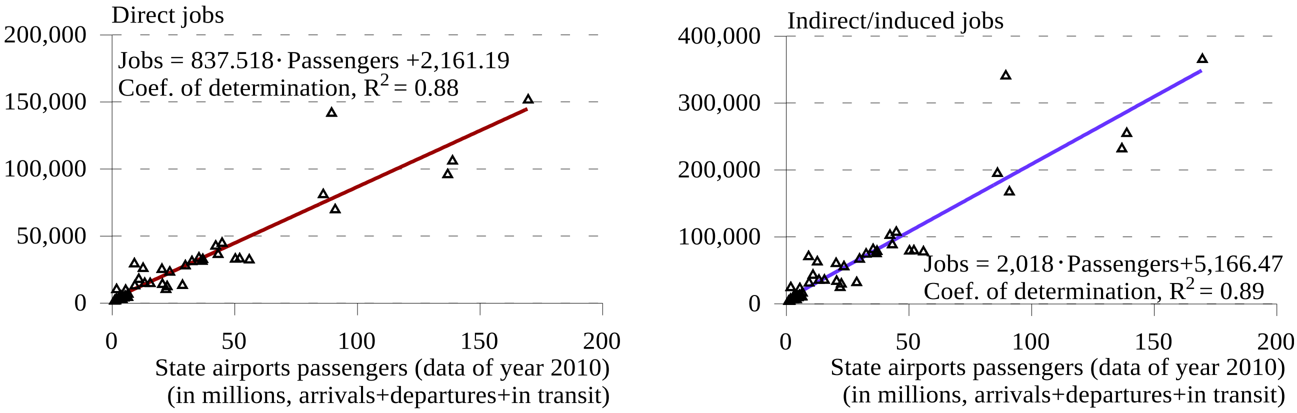

Figure 9. Correlation between annual passenger airport(s) demand and direct (left) and indirect/induced (right) jobs (compiled by the authors).

1 Bristol Airport (United Kingdom), Burlington International Airport (Vermont, USA), Calgary International Airport (Canada), Canberra International Airport (Australia), Charlotte Douglas International Airport (N. Carolina, USA), Chattanooga Metropolitan Airport (Tennessee, USA), Chicago O'Hare International Airport (Illinois, USA), Frankfurt Airport (Germany), George Bush International Airport (Houston, Texas, USA), Halifax Stanfield International Airport (Nova Scotia, Canada), Hartsfield-Jackson Atlanta International Airport (Georgia, USA), Indianapolis International Airport (Indiana, USA), John F. Kennedy International Airport (New York, USA), London Gatwick Airport (Great Britain), London Heathrow Airport (Un. Kingdom), Los Angeles International Airport (California, USA), Manchester Airport (United Kingdom), Miami International Airport (Florida, USA), Montréal–Mirabel International Airport (Quebec, Canada), Munich Airport (Germany), Newark Liberty International Airport (New Jersey, USA), Norfolk International Airport (Virginia, USA), Paris Charles de Gaulle Airport (France), Philadelphia International Airport (Pennsylvania, USA), Pierre Elliott Trudeau International Airport (Montréal, Canada), Richmond Airport (Australia), Richmond International Airport (Virginia, USA), Ronald Reagan Washington National Airport (Virginia, USA), St. John's International Airport (Canada), Sydney Airport (Australia), Toronto Pearson International Airport (Ontario, Canada), Victoria International Airport (British Columbia, Canada), Washington Dulles International Airport (Dulles, Virginia, USA), Waterford Airport (Ireland), William P. Hobby Airport (Houston, Texas, USA).

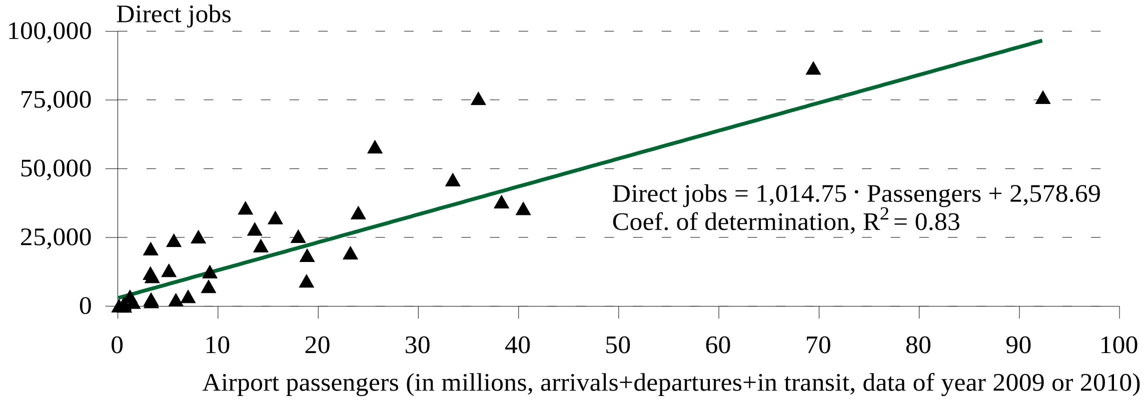

Figure 10. Correlation between annual airport passenger demand and direct jobs, (compiled by the authors).

The 21st edition of Cushman & Wakefield's survey on Europe's major business cities demonstrates that external and international transport links of cities were regarded as "absolutely essential" to businesses making location decisions [14]. Although air transport links are not explicitly included as a measure in the survey, there is a good correlation between the number of passengers handled by the city airport(s) and the ranking of the city as far as external transport links is concerned, (Fig. 11). Rank '1' means that the city has the maximum transport links compared to other cities.

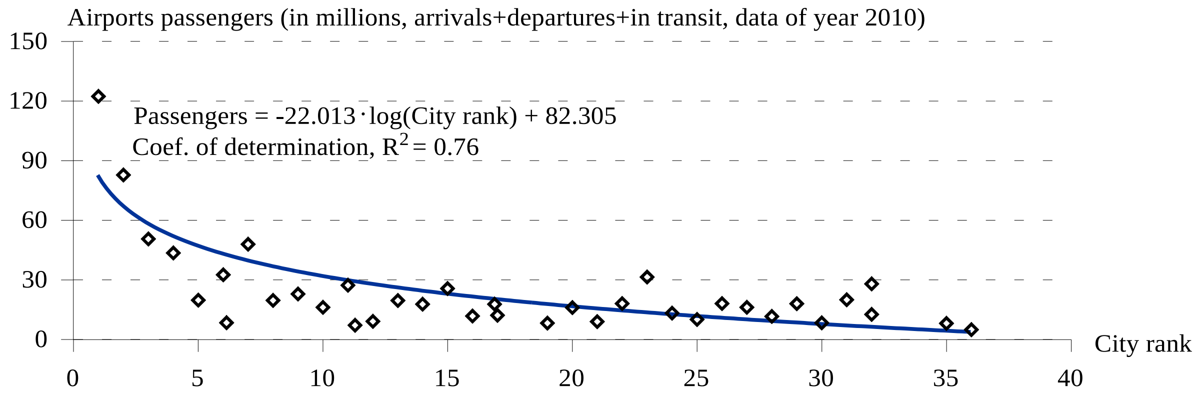

Figure 11. Correlation between citys' airport(s) passenger demand and the attractiveness of city external transport links (compiled by the authors).

4.2 Roads

Table III illustrates jobs created during the construction of a highway infrastructure in the USA, whereas Table IV illustrates jobs created during the period of construction of a toll motorway in Europe (France). Direct jobs are related to the site and in head office and comprise the operations such as design, land clearance, earthworks, drainage, engineering structures, pavement, safety equipment, buildings and plantations. Indirect jobs are linked to manufacturing of site supplies (quarry materials, cement, power, transport services, steel, wood, equipment, etc.). Induced employment generally includes all of the jobs supported by consumer expenditures resulting from wages to direct and indirect employment.

Concerning the jobs created during the operation of a road infrastructure, we will distinguish the following [15,16]:

- Direct jobs, required to operate motorways. They take into account both permanent and temporary jobs and include toll jobs, other concessionary company jobs (jobs in the regional operating divisions, districts and maintenance centers), jobs generated by sales of fuel (and related products) and by catering, jobs related to motorway maintenance works and police jobs.
- Indirect jobs. Indirect jobs are related with operating the motorway, generated by intermediary consumption of sub-concessionary companies and linked to salaries paid to employees.

Table V gives the employment effects of the operation of a new toll motorway in France (road axle A10: Bordeaux–Poitiers) with a length of 230 km and an average daily traffic of 20,000 vehicles per day. However, a percentage of almost 75% of direct sub-concessionary jobs were moved to this category from jobs on the roads which existed prior the construction of the new motorway and only the 25% are job creations provoked by the generated and diverted traffic demand of the new motorway (about 30% of the total traffic demand).

The employment impacts of road infrastructure investment do not remain constant over time. Increases in construction materials prices and wages over time will tend to reduce the number of jobs supported and other factors such as changes in worker productivity and consumer's typical rate of savings will also affect the average number of jobs supported.

TABLE III. AVERAGE DIRECT, INDIRECT AND INDUCED EMPLOYMENT EFFECTS (JOB× YEARS) IN THE USA PER 1 BILLION $ FEDERAL EXPENDITURE ON ROAD INFRASTRUCTURE [17].

	1997	2005	2007
Direct jobs	19,584	12,572	11,921
Indirect jobs	6,939	5,604	5,405
Direct + indirect jobs	26,523	18,176	17,326
Induced jobs	21,052	18,311	17,453

TABLE IV. DIRECT AND INDIRECT EMPLOYMENT EFFECTS (JOB× YEARS) OVER THE WHOLE DURATION OF THE CONSTRUCTION OF A TOLL MOTORWAY AND FOR EXPENDITURE OF 0.2 BILLION € (NET) [15].

Direct jobs	1,210	Indirect jobs	1,230
- on site and at head office		- linked to manufacture of supply	660
		- upstream the site of project	570
Revenue effect	800		
Total number of jobs:	3,240		

TABLE V. EMPLOYMENTS EFFECTS (DIRECT AND INDIRECT JOBS PER KM) FROM THE OPERATION OF A TOLL MOTORWAY IN FRANCE [15].

Direct jobs:	3.4	Indirect jobs:	2.2
- of the concessionary company	1.3	- of sub-concessionary	1.4
- of sub-concessionary companies	1.3	- due to maintenance	0.3
- due to maintenance	0.4	- linked to salaries	0.6
- police	0.4		
Total number of jobs (per km):	5.6		

4.3 Ports

In 2007, ports in the United Kingdom are estimated to have directly employed 132,000 people, whereas the ports indirectly support 150,000 jobs. The induced effects of the ports sector, measuring the impact of consumer spending by those employed in ports or directly in the supply chain were estimated to around 80,000 jobs. Adding together the direct, indirect and induced impacts, ports in the United Kingdom were estimated to have supported 362,000 jobs in 2007, representing 1.2% of the total state workforce [18].

In the United States, total direct and indirect annual impact of the USA port industry includes (in 2006) 13.3 million jobs [19]. Approximately, every 1,000 tones of cargo support directly and indirectly 0.80 jobs in the USA and 0.55 jobs in Europe.

4.4 Railways

Rail transport is critical to commute, commerce and the health of local, national, and global markets. No other system of ground transportation can move high volumes of passengers, goods and products like railways, which assure less environmental effects compared to other transport modes.

According to U.S. Department of Commerce data, every $1 of investment in rail infrastructure (track, locomotives, bridges, etc.) generates another $3 in economic activity. That’s a 200% return on investment. Additionally, each $1 billion of investment in rail infrastructure to expand capacity creates an estimated 20,000 jobs nationwide. One direct rail job supports another 4.5 jobs in factories, power plants, distribution centres and other businesses served by rail [20].

5. Infrastructure Improvement and Reduction of Transport Costs

Fig. 11 illustrates interaction between improvements of transport infrastructure and reduction of transport costs. However, transport costs as a percentage of the total cost of a product range between 10% and 30%, with a mean value of 20%. This means that only a substantial reduction of transport costs may lead to a spectacular possibility of reduction of the final cost of a product.

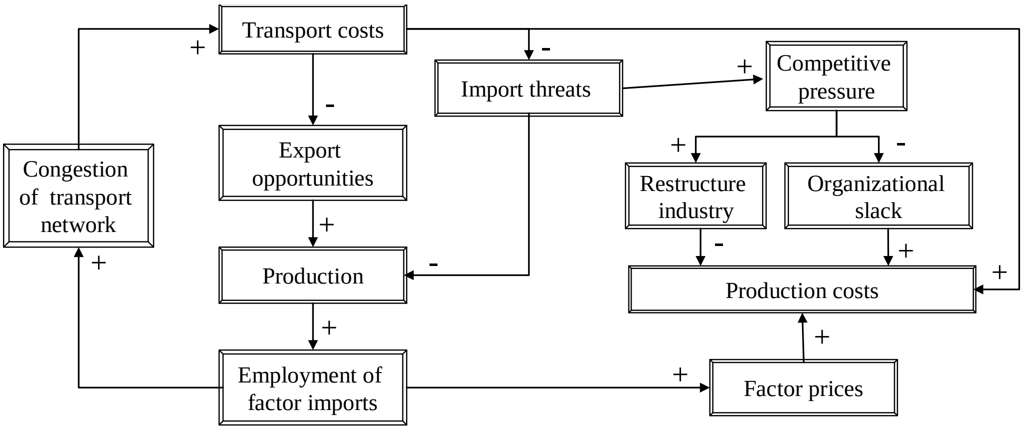

Figure 12. Improvements of transport infrastructure and reduction of transport costs [21].

6. Conclusions

The controversial relationship between transport infrastructure and economic development was first analyzed in this paper. Prerequisites for a positive effect of improvements of transport infrastructure to the economic development were detailed. We tried to survey whether a causal relationship between transport infrastructure and economic development can be established. Based on statistical and bibliographical data, we can conclude that road infrastructure and air transport activity are causally related to GDP with coefficient of determination (R^2) of 0.73 and 0.80 respectively. No correlation between rail infrastructure and GDP can be established, since R^2=0.46. However, high coefficients of determination between airports' passengers and direct and indirected/induced employment testify a high correlation between GDP and the air transport activity.

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