



Analysis of factors influencing the development of transport infrastructure until the year 2030 – A Delphi based scenario study

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ABSTRACT

In this paper, we present the findings of a web-based real-time Delphi study concerning the factors which will influence the future development of the transport infrastructure until the year 2030. Intensifying globalization, increased urbanization, ongoing shortages in public finances, and the requirements of a more demanding and growing world population are some of the challenges, which global transport will face. This research identifies, assesses, and integrates long-range developments of various factors, such as supply and demand, financing, competitiveness, and sustainability, which will affect the future of the transport industry and its infrastructure. Results are presented in a final probable scenario, which is divided into four different scenario aspects. Moreover, managerial and governmental implications for strategy and policy development are discussed.

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1. Introduction

Transport infrastructure is the backbone of global trade and globalization. It provides crucial services, is a major force in society, and is the basis for planning investments in industry and trade [1,2]. Furthermore, the presence or absence of transport infrastructure has a significant effect on economic growth. Thus, the current global economic recovery is strongly dependent on the capacity of ports, highways, railways, and airports [3].

Infrastructure systems, such as roadway and railway networks, have commonly existed over a long period of time, which affects the inertia of the overall system [2]. Therefore, forward-looking planning processes are crucial to such systems' success. Disruptions to the systems, such as traffic congestion and time delays, reduce business profits, forcing companies to rethink their long, complex supply chains [3]. Consequently, companies as well as governments face tremendous challenges with respect to the future development of transport infrastructure.

Demand-oriented transport infrastructure planning, as well as the provision of adequate financial resources, is crucial for the development of markets and economies. On a global level, by 2030 it is estimated that an investment of more than US\$41 trillion (thereof US\$7.8 trillion for roadway and railway, and US\$1.6 trillion for air/sea-ports, period 2005–2030) will be required for infrastructure development to modernize obsolescent systems and meet expanding demand [4]. Furthermore, the OECD Report on Infrastructure 2006 states that during the period of 2010 to 2030, US\$220–290 billion per annum will be required for the construction of road transport infrastructure, while the new construction of railway infrastructure will require US\$49–58 billion per annum [5]. These figures impressively underline the importance of financial resources for future transport infrastructure development. Therefore, in this paper we address the questions: (1) *How will financial aspects contribute to the future development of transport infrastructure?* (2) *How will the supply and demand of transport infrastructure evolve by 2030?*

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While the basic supply of transport infrastructure and related financing strategies is essential to ordinary logistics and mobility demands, the challenge of international competitiveness in transport infrastructure is becoming more evident. Countries require a well-developed transport infrastructure to compete internationally and to provide a high level of accessibility in terms of traffic and goods flows [6]. We contribute to this topic via our third research question (3) *How intense and relevant is the linkage between economic competitiveness and transport infrastructure in the year 2030?*

Furthermore, finding an acceptable balance between promoting economic growth, via expansion of transport infrastructure, and protecting the environment, will remain a critical issue in the future. While economic growth is often defined as a major objective, it is also critical to understand how projects will affect the environment [7]. Stakeholders, including decision makers in governmental institutions, infrastructure planning companies, as well as transport infrastructure users and operators, have widely understood that infrastructure can have a tremendous impact on the overall environment. This leads to our fourth research question: (4) *How will aspects of sustainability affect the future development of transport infrastructure?*

Taking the highly dynamic and challenging environment into account, stakeholders cannot prepare for *one* single future to come. Decision makers have to consider many different variations of the possible future and take high uncertainty into account, for example uncertainties about future external developments in the long-term, future transportation demand, mode choices, and how these choices affect accessibility, environment, and safety [8]. A broad spectrum of possible future long-term developments has to be addressed with reasonable approaches and valid methodologies, enabling broad planning perspectives [9,10]. One of the most adequate methods for addressing possible future developments, long-term planning and decision making in uncertain situations is the scenario planning approach [11]. Many applications in science and practice underline that scenario planning presents one of the most appropriate long-term planning tools [12–14]. The scenario planning method was developed to particularly support policy-makers and business leaders, facing decisions with uncertain future outcomes [15].

By analyzing our four research questions, we conclude with one probable future scenario – incorporating four different scenario aspects – addressing those conditions which are considered most likely to shape the future of transport infrastructure. The scenario aspects are based on the results of an Internet-based real-time Delphi survey [16] based upon earlier works of Gordon and Pease [17]. Our results support decision makers and planners in defining strategies or in testing the robustness and appropriateness of strategies that are already in place. Furthermore, we present managerial as well as governmental implications.

The remainder of our paper is structured as follows: After providing an overview of the literature relevant to our research and identifying the research gap, we describe the research methodology. We present the results of our Delphi study as well as four individual scenario aspects. Finally, we conclude by delineating general governmental and especially managerial implications.

2. Literature review

Scenario planning and foresight techniques are already well established in decision-making [18,19]. Particularly within long-term planning, the scenario technique is an approach that “informs decision-making in contexts of highly uncertain future conditions”, as Frittaion et al. [20, p. 421] recently stated. Consequently, decision makers require information concerning what the future challenges in politics, economics, society, and technology will be. Therefore, determining the probable future is obligatory. Within our literature review, we found that many organizations, particularly research and governmental institutes, apply scenario planning and techniques in order to investigate future challenges in the field of transport infrastructure.

Loorbach et al. recently determined that research in the field of infrastructure systems has a long tradition. The research, in general, “has focused on a single sector, has often been mono-disciplinary in character (technological, economic, behavioral), and focused on specific system elements (rather than the whole system) and their optimization (rather than fundamental change)” [2, p. 1196]. Furthermore, published studies and papers are often limited to urban or regional topics. For example, since the late 1980s, especially transportation scenario planning projects concerning regional land-use have been carried out extensively in the US [21].

A plethora of scenario research in the field of transport infrastructure has been conducted over the last decades. Researchers have applied various scenario techniques, which were based on different study designs and data bases. Although Still et al. [22, p. 85] stated that “The Delphi method has not been applied widely in transportation studies,” some valuable Delphi studies were indeed conducted during this time.

Within our literature review we first provide an excerpt of journal articles and papers that deal with long-term scenario planning, which essentially apply the Delphi technique, in the context of transport infrastructure. Thus, we are able to demonstrate how our own work contributes to existing work in the field long-term. Second, we provide an excerpt of government studies applying the Delphi technique as well as other techniques. Tables 1 and 2 provide an overview by classifying the literature in terms of type, planning horizon, and research details including characteristics of the chosen study design and thematic scope. We assess the articles and reports within a specific scope, namely geographic focus (e.g. regional, global) and discipline (e.g. technological, economic). Due to our long-term approach, we only list articles and reports with a minimum time horizon of 10 years.

We applied SCIRUS and ScienceDirect search engines to search the literature using three basic terms, “transport infrastructure”, “Delphi”, and “scenario”: SCIRUS provided 41 hits within journal sources. However, most of these published journal articles (38) were also hosted by ScienceDirect. The remaining three studies were hosted by Pubmed Central and did not entirely correspond with our research objectives. The ScienceDirect search engine provided 78 findings regarding “transport infrastructure” and “Delphi”, whereof 74 articles were published in journals. Applying the search “scenario” within these results gave us 49 findings. We reviewed these 49 articles in terms of our research objective. Many dealt with traffic and transportation

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