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Article

Trade-Offs in Competitive Transport Operations

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Abstract: One of the goals of developing a transport corridor is to promote socio-economic development by improving connectivity and sustainable transport operations, which largely depends on the operational strategy. Trade-off policies can be important tools for gaining the competitive advantage of road transport corridors, and thus, help facilitate sustainable growth and welfare. This article uses a case-based approach to observe the trade-offs in the first phase of transport infrastructure development, and then, in the second stage, further explores the trade-off variables in the transport operations strategy under the China-Pakistan Economic Corridor (CPEC). The results from the three cases of the parallel route system of the CPEC indicate that trade-off is an easily understandable and applicable method, which can foresee the operational gains or compromises for significant welfare of the regions. The implications of the trade-off are two fold, first is the “importance” of the trade-off, which is related to its impact on operational competitiveness. The other is the “sensitivity” of the trade-off, in terms of the change that will be caused to one variable when changing the other. The trade-off concept can be used for several landlocked transport corridors to achieve a competitive edge in transit trade.

Keywords: trade-offs; transport operations; competitiveness; sustainability

1. Introduction

Over the last two decades, emerging markets have received much attention due to their substantial development relative to the rest of the world (Khan et al. 2020), while the concept of the trade-offs is not mysterious; in fact, it is potentially straightforward and adaptable. The trade-off is the balance among two variables for an optimal gain (Cheng et al. 2013). After being both praised and criticized, the importance of the trade-offs has increased in recent years. It is found to be a central approach in operations management and strategy. Since the 1970s (Skinner 1992), the trade-off strategy has been proposed primarily in processed manufacturing and productions, but the discussion of the trade-off requirements has recently continued in operational strategies (Akbar et al. 2019).

Critics argue that corporations cannot compete solely based on cost and production, but must moderately compete with multiple variables like cost, quality (Skinner 1969), variety, lead-time, delivery, and flexibility (Da Silveira and Slack 2001; Boyer and Lewis 2002). Numerous scholars

have challenged the authenticity of the trade-off methods. Collins (Collins et al. 1998) discussed the trade-offs by providing empirical support to the models and suggests that there should be no trade-off between quality and delivery in any system designed to improve simplicity and level of discipline. Similarly, (Shahbazpour and Seidel 2007) consider trade-offs as constraints by arguing that trade-offs can be eliminated by applying the creative space-time problem-solving theories. The trade-offs are also associated with the paradigms in resources, which are challenged by one of the Searle Medical Instruments case studies. The case study suggested that, in reality, paradigms can improve many operations but cannot eliminate trade-offs (Clark 1996). Therefore, the concept of trade-offs has been perceived as wrong. Considering the trade-offs definition from an operations management perspective, it is the balance (between two expectations) which benefits the most, and, thus, there is no more room for trade-offs (Akbar et al. 2019).

In a broad-spectrum, by considering the road transport operations as the means to cope with a country's development challenges (i.e., welfare through regional integration), the trade-offs among prioritized operational variables (i.e., travel cost, travel time, routing flexibility, traffic information, and road capacity, etcetera) must emphasize consistent improvement. This research adds a valuable contribution to the existing literature of road transport operations management and opens the discussion for researchers by posing a question: "Can the competitive transportation factors, such as transport infrastructure, transport services, logistical technology, and transport policy, enable the trade-offs among operational variables?" The findings suggest that they can enable the trade-offs if the choices are made regarding critical competitive factors, e.g., to decide a factor that should receive the most significant investment of resources and infrastructure. The adjustable trade-offs, as the road transport operations technique, contributes to the consistent outcomes in the long run. Figure 1 shows the idea of the stage, where operational factors can enable trade-off among operational variables for sustainable growth.

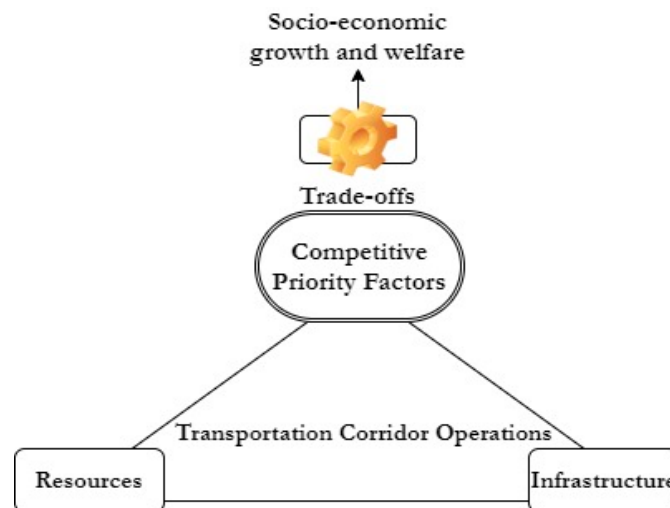


Figure 1. Operations strategy model for the transportation corridor.

We aim to find an answer to the question of whether trade-offs among competitive attributes in road transportation play roles in achieving sustainable socio-economic growth. We take the case of the China Pakistan Economic Corridor (CPEC), and it is momentous to know the pre-developed transportation infrastructure of the CPEC. In this study, the northern route of CPEC, which (at one end) connects with China, is considered as a series route system. The other end of the series route system is connected with the three highway road routes termed as a parallel route system, i.e., central route, western route, and eastern route. We collect official referenced data of the parallel highway route system of the CPEC. The trade-off decision made during the highway construction phase is observed. The second phase of the CPEC (i.e., road transportation during industrial development) was carried out

to identify the trade-offs, which may help to obtain a competitive transport business, thereby promoting socio-economic growth. The findings may also be applicable to operations management in different landlocked countries, where road transport works as a backbone to their economies. The following sections of this paper include literature, methodology, case study, propositions, and conclusion.

2. Literature

2.1. Trade-Offs and Social Impacts of Transportation

A provincial report by Kaiser Bengali showed trade-offs of transport routes in the Balochistan province of Pakistan (Bengali 2015). There was a route controversy and much pressure faced by the federal government to start the operational trade with existing highways of Pakistan, which majorly consist of the eastern route. This was because of the huge investment required for the western route due to its high land-acquisition cost. The trade-offs considered for the western route of the CPEC had lessened the land acquisition cost and enabled the mutual consensus on building a new route; see more details in the provincial report (Mohmand and Wang 2014). This trade-off decision had not only reduced the cost but also enhanced social connectivity and opened doors to better education, employment, and businesses for the neglected backward regions of the Balochistan province. Similarly, (Heshmati et al. 2019) took the case of challenged trade-offs between welfare and economic growth and argued that there is a need for better understanding of the causes of income inequality.

Mohmand and Wang statistically proved the positive impact of transportation on social connectivity. Before CPEC, due to political conflicts, many land areas stayed unconnected. The improvement in the construction phase of highways won the hearts of the people from backward areas of Pakistan. Their findings pointed out that the transport infrastructure investment had improved not only accessibility but also enhanced opportunities for trade and investments (Mohmand et al. 2017). Ali and Mi showed a positive impact of transport connectivity on education and employment by providing easy access to basic services. In the following year, in 2018, they considered the crucial impact of road and transportation on society. They explained both favorable and adverse influence of transport on the local people by using factor analysis and structural equation. However, the overall impact of road and transportation on society and economy was still directly positive (Ali et al. 2018). In addition, Zhang used the concept of “vulnerability to assess the social impact of transportation, and showed that the integration of sourcing strategies with social impact assessment proved to be a better tool to benefit the local communities of development projects (Zhang et al. 2017).

Garlick, in 2018, points out that the overland connection is beset with challenges in the operational phase even after having the infrastructure developments, and hence, the positive impact of transport can be seen in the long run (Garlick 2018). The social impact of transportation is a broad subject where it is deemed to bring prosperity to the region. There are also many factors like insecurity, man-made disaster, and accidental rates that harm the image of the CPEC, and hence, deter investments (Black 2009). Mengsheng, a professor at Peking University, pointed out new challenges in the second phase of the CPEC, which is the phase of industrial development. Out of many challenges, there is a need for foreign capital inflows to cope with the serious fiscal deficit, and the most important, it demands the trusted commodities trade that is free of security and political conspiracy threats. The author elucidated that these are the internal factors that are affecting the CPEC (Zhang et al. 2017).

2.2. Recognizing Trade-Offs and Challenges

Trade-offs can be visualized in different ways. One way of picturing the trade-off is that it is a function of two variables, which can also be plotted graphically, and the other is related to multivariable. It helped to predict the performance of variables in routine processes (Hayes and Pisano 2009). An additional proposition defined a new element besides the trade-off function known as a pivot of the trade-off. The rise in the pivot helped to overcome the trade-off and hence led to the performance improvements. However, in this literature, the author did not describe which elements of an operational

system represents this improvement, despite the bright ideas of attitudinal and technical constraints (Slack 1991). This pivot was later explored by Silveria in 2001, where the author defined internal (the attributes) and external (competitive objectives) performance measures in trade-offs using the case-based studies. The author elaborates that the internal factors measures were the pivots in the trade-off model, whereas the external factors measures were their variables. Moreover, the role of internal variables are illustrated as a combination to improve pivot (whenever trade-offs overcome) (Da Silveira and Slack 2001). The trade-offs have also been identified with the help of mathematical support, such as, Akbar et al. (Akbar et al. 2020) use the data envelopment analysis (DEA) to calculate the efficiencies of nineteen countries along with the Belt and Road Initiative (BRI). They identify that the slacks show the due trade-offs in the form of excess values in bad outputs and inputs, whereas, shortages in the good outputs.

After the 1970s (with the introduction of the trade-offs), the 1990s (with facing challenges), and the mid-1990s onward had been majorly concerned with compromises between trade-off factors. All these years, the trade-off concept is used mainly as a tool to achieve an ambitious objective for improvement. Later, the significant progress in the subject is seen by the contributions of the Gibson trade-off rules, suggesting acceptable criteria to evaluate consistent trade-offs (Morrison-Saunders and Pope 2013). Gibson et al. presented a political tilting approach for decision processes in trade-offs, such as prioritized positioning of resources between two activities, and a decision on a priority action when to push a little further (Gibson et al. 2005). Skinner and Hayes, in their conceptual studies, suggested that conglomerates should focus on one priority at a time (Amit and Schoemaker 1993; Hayes and Pisano 2009). This implies that irrespective of the industry type (i.e., manufacturing plant or road trading corridor), the cost, flexibility, and delivery requires different and improved operational structures and infrastructures.

Given the unsuccessful efforts in proving the trade-off concept as wrong, the heated debate grew over the recognition of the relevant concept that was being misunderstood. The implication of this concept is the appropriate "positioning" of competitive factors as an initial task of an operations strategy, by focusing on a narrower set of objectives. Even the recent studies explored the ways that helped in recognition of the characterized positioning and the consistency of that positioning by the adoption of resources and procedures (Thomas et al. 1985).

2.3. Trade-Offs for Sustainability

In 2019, Quium elaborated that there can also be essential trade-offs among social welfare, financial system, and environmental quality (Quium 2019). Even with evolution in managerial practices due to IT (information technology) advancements, strong trade-offs are considered compulsory to realize sustainable e-commerce (Oláh et al. 2018). According to Blankespoor, if a transportation corridor generates balanced social well-being and economic growth in the corridor region (Blankespoor et al. 2018), then the trade-offs can become a tool to keep sustainable socioeconomic growth with consistent competitiveness. To the best of our knowledge, there is little noticeable writing that has discussed trade-off in the business conglomerate, but trade-off is not explicitly found in the transportation corridor operations, particularly for the contribution of sustainable socio-economic growth. It was mostly discussed as an influential factor, for instance, Skinner suggested that even the simple operations without the trade-offs cannot be sustained (Skinner 1992). This is because the level of consistency among the competitive priorities and decisions regarding the operational processes can better determine the efficiency of operations (Leong et al. 1990).

Zimm et al. found a holistic approach to assess the inherent synergies and trade-offs between sustainability gaps in business, environmental, and social goals. They recognized the potential for multiple trade-offs and synergies between the Sustainable Development Goals (SDG) and concluded that trade-offs should not be seen as permanent but as indicators of the need for transformation (Zimm et al. 2018). Saunders and Pope argued that for the right positioning of trade-offs, sustainability requires an explicit assessment during internal (development phase) and external (approval decision

point) phases (Morrison-Saunders and Pope 2013). Utne took a slightly different approach and discussed the trade-off analysis of sustainable attributes for the fishing fleet along with decision-making methods (Utne 2008). This implies that, whether it is a manufacturing company, a transport company, or a transport corridor, sustainable growth is dependent on the prioritized decision among the competitive factors. The trade-offs involve not only the priority of the competitive dimensions but also the rate of improvement in them, which makes the trade-off a more balanced and harmonious approach towards sustainability. A question crops up that “what are important competitive factors in transport corridors’ operations?”

2.4. Competitive Trade-Offs in Transport Operations

Considering the economic consequences of transport infrastructure (Rehman et al. 2020; Khan et al. 2020), the competitive trade-offs call for optimal balance between the factors, which also demands management focus, a thorough investigation before the trade-offs should take place. Though the standard framework for transport operations is already well known, the question over the relationship between competitive priority factors is continuous and evolving with technology. Three models, such as the cumulative, the integrative, and the trade-off model, are supporting this debate. However, the trade-off model seems to be the most established, but regardless of any of these models, the operational strategy is viewed as the correct positioning capability of competitive factors.

Strategic theories repeatedly stressed the four necessary capabilities (competitive factors), such as cost, quality, delivery, and flexibility (Ward et al. 1998; Hassan and Azman 2014). These factors help to ensure that the road transport network is linked to national growth at the micro and macro levels (i.e., national output, employment, income, production, wages, jobs, low inputs, and high outputs). To attract international industries, the most quoted examples for high-quality standards were investors’ needs (flexibility), reliability (delivery), and efficiency (cost) (Szwejcowski et al. 1997). Ferdows and De Meyer further explained the same three factors with the help of the “sand cone model”, to capture the advanced capabilities (Ferdows and Meyer 1990). There is limited literature that has taken trade-offs as a tool to gain sustainable growth in the business conglomerate; however, the extant literature is lacking the trade-offs for the transport operations.

3. Research Methodology

A case study approach is adopted because case-based research is found to be a suitable method to conduct empirical studies or to prolong exposed debates (Eisenhardt 1989). A qualitative approach is used for two reasons; first, this research aims to focus on “how” trade-off can play a role in transport operations for sustainable developments, which is mostly found appropriate for descriptive studies (Da Silveira and Slack 2001). Secondly, this research intends to establish the trade-off theory for competitive road transport operations, in the light of real facts and figures, rather than testing it.

The data collection for the parallel route system of the CPEC comprised of five actions:

1. Observation of the overall CPEC routes and the seaports connected to it (www.cpec.gov.pk). An informal discussion is performed with the CPEC officials and the major logistics operators in Pakistan i.e., Costa Logistics, MG Sky Cargo, Akurate Services, Agility, and Silk Goods Transportation.
2. To quantify the cost, safety, and profit of each highway route, we adopt the probability density function (PDF) and use the cumulative probability. This is to propose the effective trade-off types in the proposition section. The results are conducted using assistance from a website www.vertex42.com, simulation graphed by Witter in 2004. The results are shown in Appendix A.
3. Discussion and calculation on unsafe probabilities of each route are done by taking factors like natural disasters, terrorism (National Counter Terrorism Authority Pakistan, www.nacta.gov.pk), and accidents (National Highway Annual Performance Report, www.ntrc.gov.pk) using Microsoft

Excel between the years 2010–2018. These factors were chosen to know the current investment atmosphere after the infrastructure development of the CPEC.

4. The important transport factors, such as infrastructure, transport services, logistical technology, and transport policy, are selected from the related literature (Akbar et al. 2019; Rehman et al. 2020). Moreover, the important transport variables (i.e., transport cost, reliability, information, capacity, and route insecurity) are also selected from citations (Mohmand et al. 2017; Ali et al. 2018). The importance of each route of the parallel route system is judged by using three factors, i.e., population density, the total area of cultivation, and the production of four major crops (Bengali 2015).
5. Follow up emails, real-time news, and latest updates were kept align to authenticate the interpretations (www.cpecinfo.com).

Since specific provincial governments dominate each highway route, i.e., the western route majorly comes under the Balochistan, most of the eastern route is under the Punjab control, and the central route crisscrosses the boundaries of two provinces, the above activities are intentionally carried out for each highway route. We combine the CPEC road transport factors, transport operating variables, and trade-offs with the help of three detailed case studies of CPEC's road routes. This study is meant to explore trade-off strategies that can be practiced by operational managers. The specific trade-offs variables in this study are limited to five. They are transportation cost (C), reliability (R), information systems (I), capacity (V), and insecurity (S). Transportation costs (C) consist of travel time, travel costs, and travel safety; reliability (R) is quality, flexibility, and speed. The information systems (I) include e-commerce and logistics, while capacity (V) is the ability to adapt to the volume of road traffic and types of goods. The fifth and final factor is road insecurity (S), which takes into account accidents, natural disasters, and terrorism. So, for example, the trade-off between cost and capacity is termed as a CV. By this, we are limiting this study not to involve the trade-offs, such as operational expenditure or transportation modes, but rather to match the frequently cited competitive objectives.

4. Case Study

Considering the case of Pakistan, a large amount of foreign exchange is needed to rein in colossal capital spending. The most effective way to improve the country's foreign exchange is to attract foreign direct investments for better resource utilization and financial development within the sound institutional framework (Khan et al. 2019, 2020; Abdulahi et al. 2019; Nawaz et al. 2014), which also demands both the route efficiency and effectiveness, see the report of Mengsheng and Jingfeng (Tang and Li 2019). Therefore, the three cases of highway route systems are investigated, and related data are calculated to have a better understanding of the trade-off technique for road operational efficiency and effectiveness (see Appendix A). The parallel road route cases are termed here as central case, western case, and eastern case, see Figure 2. All the information and data are official and have been fetched from the ministries' official website for the national highway authority and the CPEC authorities (Highway 2019; Bengali 2015).

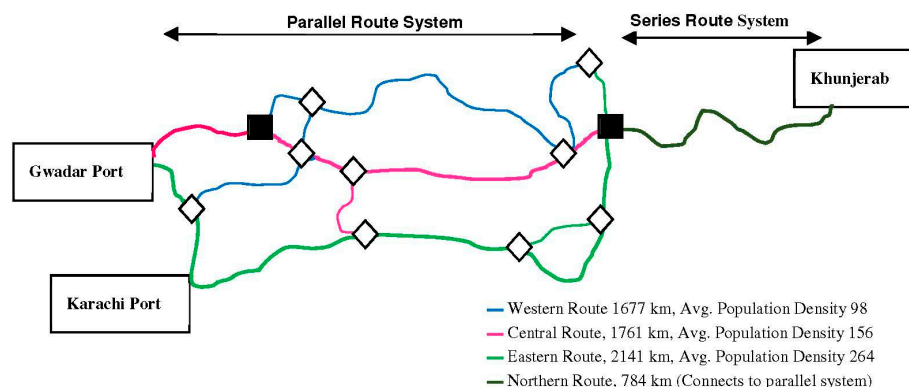


Figure 2. The parallel route system of the CPEC in Pakistan.

4.1. Central Case

The central route passes through the Balochistan province and parts of the Punjab province of Pakistan. This long-term construction of highways and bridges has opened economic opportunities for the vast number of backward regions of Pakistan. It passes through undeveloped and unindustrialized major urban nodes, namely Basima, Khuzdar, Sukkur, Rajanpur, Layyah, Muzaffargarh, and terminating in Dera Ismail Khan, and leads to Karakoram Highway through the Brahma Bahtar–Yarik Motorway. This alignment is narrow, with 2 to 4 lanes only.

It is 2423 km long and facilitates more road connections with the highways, which means it is found to be a more cost-effective and flexible route in road transportation. The total travel time is 62 h (including possible delay time) with the probability rate of 91 percent, which makes this route relatively reliable in transportation. The total traveling cost of this route (from Gwadar port to Khunjerab border) is 760 USD with a probability rate of 46 percent. The terrain along the alignment is mostly hilly; moreover, this alignment crosses the Indus River and contains a major bridge. The probability of overall insecurity, which includes natural disasters, accidents, and terrorist incidents, is 11 percent. Thus, this alignment also does not require significant diversions due to environmental and military reasons. On the other hand, the central route region entails higher land leveling costs because the average population density around the central route is 156 (per sq. km of land), which is not much. However, due to insurgencies in Balochistan and FATA (Federally Administrated Tribal Areas), the security cost is likely to be higher. Moreover, the total area under cultivation is 5829 (in million hectares), and the production of major crops—wheat, rice, cotton, and sugarcane—is 13,754 (in million tones).

4.2. Eastern Case

The length of eastern route is of 2692 km. This longest route of the CPEC passes through the Sindh and the Punjab province of Pakistan before it connects with the northern corridor. The highway routes connect the two largest cities of Pakistan (i.e., Lahore and Karachi) and consist of 4 to 6 lanes. The total traveling cost of the eastern route (from Gwadar port to Khunjerab border) is 984 USD with a probability rate of 61 percent. This route is divided into four sections, Karachi to Hyderabad, Hyderabad to Sukkur, Sukkur to Multan, and Multan to Lahore. Considering the Gwadar port as a departing place, by avoiding the Sindh highway, it goes along the shared M-8 motorway between the Turbat and the Khuzdar regions. The travel time on the eastern route is 113 h (including possible delay time) with the probability of 41 percent, indicating less reliability.

Except for the backward areas of the south Balochistan, the southern Punjab and the northern Sindh (provinces), more than half of the distance passes through developed areas of the central Punjab, which increases the convenience level of traveling on this route. The re-routing flexibility of this route is manifold and hence considered the most efficient route under the CPEC. The essential city nodes in the eastern route are Multan, Faisalabad, Pindi Bhatia, Rawalpindi, Hasanabdal, and onwards to the northern alignment. Thus, this route has a big border with India. The probability of insecurity, considering the aforementioned factors, is calculated as 64 percent. The security and safety cost is much higher on the eastern route. The average population density in the regions around this route is 264 (per sq. km of land), which is higher than the other two cases. The overall area under cultivation is 10,332 (in million hectares), and the production of major crops is 30,928 (in million tons). The eastern route is mostly plain and is likely to entail low land-leveling costs. On the contrary, the land around this route is also considered the most fertile in the country, which may lead to higher substitution costs.

4.3. Western Case

The western route of the CPEC is crisscrossing the Khyber Pakhtunkhwa, the Balochistan, and the western Punjab Province. The alignment is 2492 km long, which is shorter than the eastern route but longer than central alignment. The highway lane capacity is 2 to 4 lanes; thus, the capacity is not consistent along the route. It consists of eleven interchanges, seventy-four culverts, and three major

bridges crossing the Indus, Soan, and Kurram rivers. The total travel time on this route is 56.29 h, including possible delay time on toll plazas and interchanges. The probability of this travel time including the delay time is 34 percent. The total traveling cost (from Gwadar port to Khunjerab) is 723 USD with a probability rate of 46 percent. The rapid land development around this route has enabled the benefits of serving landlocked countries like Afghanistan, Kyrgyzstan, and Kazakhstan, etc. The newly developed special economic zones around this route are rapidly developing, but security threat is still a big hurdle in that region. This region has faced the most earthquakes in the country, and it has extreme temperature i.e., extremely hot in summer and extremely cold in winter. The unsafe probability in this case, which includes accidental rate, natural disasters, and terrorism, is 41 percent (higher than central route but much lower than eastern alignment); the security cost is still expected to be higher due to insurgencies in a neighboring province, namely “Balochistan and FATA”.

The terrain along the alignment is hilly, and land leveling cost is high, as it passes through the key city nodes, namely Brahma Bahtar, Burhan, and Hasan Abdal. The Karakoram highway connects to the western highway at Burhan. The average population density in this region is 98 (per sq. km of land), the overall area under cultivation is 2933 (000 ha), and the production of major crops is 7430 (000 tons), which shows that the domain is relatively unproductive. On the other hand, there are two special economic zones (SEZ) under the development stage, which will enable further road transport trade-off opportunities.

The selection of these three cases is because of their parallel nature, and the current trading stage of the CPEC, and also, because it is considered a major concern regarding Pakistan’s sovereignty (Abbas et al. 2019). There are few points noteworthy for the overall corridor routes.

- The custom posts on seaports or routes are linked with WeBOC (under Pakistan Revenue Automation Private Limited) electronically without any compliance or connectivity issues (Rana 2018). This platform will facilitate the fast movement of cargos across the country (www.weboc.gov.pk).
- The trucking business and transport industry need to be updated by introducing technologies like auto transmission and higher axle load, etc. Pakistan is one of those countries where the ministry for logistics does not exist, and the delay time problem occurs when logistic industry seeks approvals of different ministries. On the other hand, considering the CPEC developments, Pakistan is likely to become a hub of transshipment trade. Hence, the central authority for logistics becomes a need.
- The CPEC routes go through the hilly, mountainous, and hazardous terrains, and thus likely to face driving safety challenges (www.cpec.gov.pk). Hence, there is a need for logistic technologies. The improved Early Warning System (EWS) under the Pakistan Meteorological Department (PMD) (www.pmd.gov.pk) is not as yet installed, which is necessary to the trade and overall sustainable socioeconomic development.

The propositions based on the above case studies are in the following section that can help managers identify the trade-offs for a competitive road transport corridor. However, the above cases deliberately focus on infrastructure resources (highways, bridges, and safety), road capacities (number of road lanes, travel time, delay time), and land acquisition status (cultivation area, major crop production, and population density). This is to explore whether the trade-offs can be achieved through infrastructure and resources. Although the land acquisition has already taken place and infrastructure is developed, still the information is gathered to witness the previous trade-off during the development phase.

5. Propositions Based on Case Study

This section deals with the proposed categories of trade-offs and consists of nine propositions. The first three propositions are the validation of the trade-offs, the next three are the natural trade-offs

found in the parallel route system, and the rest of the three propositions are related to the differences in the trade-offs.

Proposition 1. *Trade-off in operational management.*

The trade-off concept is considered as opportunistic and simplistic. It is, in our case, to let go of some of the benefits to gain better or similar benefits with comparative advantage to keep balanced and sustainable road trading. However, it is not the continuous benefited method but always beneficial in finding the optimal balance between two factors. For example, in some cases, trade-offs are impossible because the other factors that are meant to be ignored are essential and cannot be overlooked. The authentication of the trade-off concept is to consider it as a central operational policy or strategy, even if it requires a structural modification (as in our route cases).

Proposition 2. *Trade-offs role as effectiveness.*

The usefulness of the trade-offs enabled us to form another element for the improved operational trade-off. This element, which increases the trade-off opportunity without losing much, is termed as “effectiveness.” For a valuable trade-off, we associate it with the assumptions that can be relaxed to gain benefits. For instance, the trade-off between cost and reliability of the CPEC routes depend on the attributes, such as volume and variety of trade commodity. Pakistan has significant textile and agricultural expertise; hence, the growth opportunity can be gained by improving the relative elasticity of demand using trade-offs as a tool.

Proposition 3. *Easier to understand.*

The trade-off is easier to understand on the process-based day to day operations. It is found difficult in operations when managers have to meet the targets and to prepare the batches to dispatch. For an understanding of the trade-offs, we can consider reducing road transits by reducing the accidental rate, customizing the inspections, or eliminating the security checkpoints to improve the total effort. This can also improve the trade-off between travel cost and time (the best fit in the eastern route and better for the rest of the two routes), and this will be helpful to overcome the trade-offs. Another example can be the trade-offs between reliability and capacity, i.e., the more the area is deprived of economic activities, the less consumption there will be. Therefore, there will be less demand for production and distribution; hence the trade-off between reliability and capacity may play an important role (considering the central route case). The aforementioned is similar to the finding of another study by suggesting better trade-offs between manufacturing companies ([Da Silveira and Slack 2001](#)).

Proposition 4. *Observed Trade-offs Gain.*

The trade-off nature of all three cases of the parallel route system had already changed due to China’s investment in highways infrastructure in the first phase of the CPEC development. For example, the route controversy between the provincial government and the federal government on the western route had created an unjust situation by considering the immediate CPEC operations in the eastern route (with the help of already developed industrial zones and highways). However, this could have neglected the less developed western regions in the country. On the contrary, the trade-off of a route path, considering factors as population and crops, has created possibilities to connect with landlocked countries on the eastern border. Further trade-off is observed when the western route is being redesigned considering less land acquisition cost, see [Table 1](#). It also did not neglect the compromise of the eastern route through implicit and explicit changes, mainly because the new Gwadar port connected to the western route is forcing developed companies to expand or reposition.

For example, the mature industries around the eastern route may now find it feasible to relocate their extended branch near the new seaport, e.g., Gwadar. Hence, better trade-off dynamics are already seen, and now, in the second phase, the CPEC is more in a position to work for better gains in terms of internal and external connectivity.

Table 1. Observed trade-offs of alternate routes with less land acquisition cost.

Factors	Western Route	Western Reroute ¹
Cultivated area (000 ha)	98	76
Production ² (000 tons)	2938	1838
Population density (per sq. km of land)	7430	1485

¹ Route decided at an all-party conference (APC). ² Production of wheat, rice, cotton, and sugar-cane. Source: Report by Kaiser Bengali (Bengali 2015).

On the other hand, road safety also contributes to international trade competitiveness and hence affects the overall trade. Therefore, it implies that the trade-off design strategy may be a solution for economic growth, even if it demands the development of more alternate routes or to integrate the processes. Figure 3 shows the trade-offs based on resources. The more the resources are increased, the better the trade-off level is to take place. For example, with improved highway infrastructure, we are now able to use the transportation trade-offs for better international trade competitiveness. Likewise, when the resources are increased, we shall be able to control the volume of trade more effectively, and hence the trade-off between cost and volume plays a more vital role in transit trade growth.

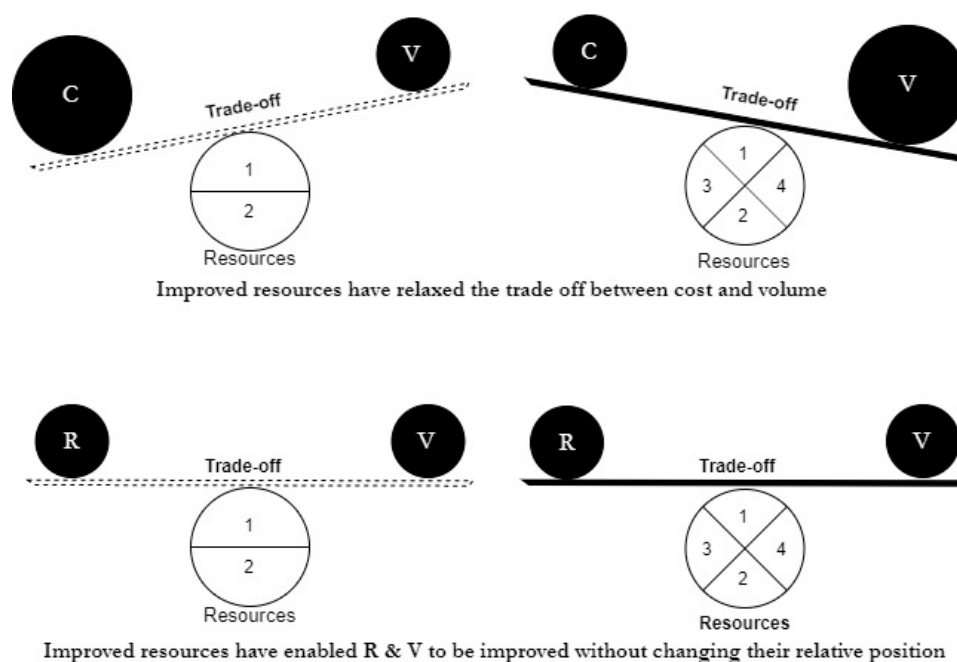


Figure 3. Categorized trade-offs. The dotted and the filled lever shows the weak and strong stage of pivot respectively.

In some cases, improved trade-offs can be made without losing the relative position; in fact, it causes the other factors to grow. It is seen habitually in the provincial transaction but can also be done in international trade transportation. For example, the trade-off of RV (transport reliability versus capacity) is already improved in complying with the policy of ease of doing business or transit procedures, which is used to attract the business firms (both domestic and foreign), and this has also improved the trade-off factor of “transport cost”. There are cases when trade-offs are to be made traditionally, that is, to achieve a competitive objective at the expense of the other. For instance,

the trade-off between road transport reliability (R) and road transport safety (s) to gain the process integrity, where more travel safety can be a competitive advantage, but it may cause the indirect cost to increase. Lastly, a few examples are found where improvements can be made by trading-off one or more assumptions together for higher gains. This paper does not explore these assumptions because it is possible that each trade-off assumption has to wait for its related sequence of actions before it can take place.

Proposition 5. *Trade-offs Conflicts.*

In the trade-off literature, there is no evidence that trade-offs conflict with growth and improvement for any reason. The implementation of the trade-off concept must stress the acceptance of trade-off as continuous improvement and should never conflict with the idea of constant development. For example, to gain a competitive advantage among the belt and road countries (BRI countries), the level of trade cost minimization should not deteriorate the quality process of the CPEC. On the other hand, the trade-off can be applied as partial or can be ignored. For example, the trading commodity on western route demands high safety while the western case has insecurity probability 41 percent. In this scenario, ignoring route trade-offs and putting the commodity on the safest route may be a solution but also may result in an extra trading cost.

Proposition 6. *Overcoming different trade-offs or trade-offs with similar effects.*

It is essential to know how the resource investment can enable many trade-offs to overcome. Once the relative gains have been achieved to a certain maturity level, then there may not be a need for further trade-off assumptions. It implies that overcoming a trade-off requires an assessed investment in the light of the selected essential trade-off assumptions that may have a significant effect on the operations strategy. For example, in central and eastern cases, the speed of learning and innovation through logistic technology may enable the RV (transport reliability and capacity), which is improving transport reliability at the cost of allowing limited capacity. Otherwise, opening to the variety of commodity trade may require the investment in docking warehouses. In the eastern case, the investment in the range of route segments (improved infrastructure) can improve its connectivity with the western case (which has a nearest and direct connection with Gwadar port), which reduces the cost and increases the reliability. Hence, the trade-off between transport cost and transport reliability (CR) can rise to the maturity level. On the other side, trade-offs may have similar effects on investments in all cases. For example, assuming trade-offs with relaxed taxes (transport cost 'C') and an increased variety of commodity trades (capacity 'V') will have a similar effect of gaining inclusion (socio-economic welfare). So, asking the question "what investments are essential to overcome trade-offs?" may equally be necessary to know how peculiar investments can overcome many trade-off factors.

Proposition 7. *The trade-offs types will vary from case to case.*

The degree of impact due to trade-offs is termed here as the "importance" of a trade-off (Sarmiento 2011). Each of the three cases has different nature of trade-offs that impacts its overall performance. The central case is mostly barren and has the least economic activities, so the change in the trade-off assumptions may hardly make visible performance. This makes the trade-offs in the central case less important, and hence the central case may require more investments' trade-offs rather than transportation trade-offs. The traditional trade-off (which is to achieve one competitive objective at the cost of the other) may work well with the eastern and western cases, while the trade-offs without losing the relative positions/status of its assumptions fit for all cases (i.e., not to ignore it completely but rather trading it off partially for a balanced trade-off). Since it is not intended to opine further on the importance of the individual trade-off factor concerning the rate of impact, it is worth mentioning

that the trade-offs with strong influence are related to “benefits” and hence are essential in transport operations, especially the CR (transportation cost and transport reliability).

Proposition 8. *Importance determined by important factors.*

Logically, the significance of a trade-off always determined by factors that are influential for welfare gains from international trade. In the CPEC road trading, the selected factors are linked to the behavior in which Pakistan chooses to constitute its trading strategy as a comeback to the international market. As prioritized, these factors consist of infrastructure, assisting services, logistic technologies, and policy/regulations for the growth of integration, cooperation, welfare, and industrial growth. These factors are further explained as follows:

- The infrastructure allows imports of much-needed capital goods to enhance economic activity. It allows the small cities and rural regions around the corridor to be well connected, and thus, it will increase job opportunities, education, and ease of doing business.
- The number of services is the logistics services to dominate internationally in the core comparative transportation. It allows the rural and urban regions to involve in learning innovation and technological developments.
- Logistic technology brings ease of doing trade on the CPEC routes. Lower price distortion is one of the viable factors that has an adverse effect. The technology will help in preventing corruption and improve the process by bringing equity among rich and poor people.
- Policy/regulations work in two ways in our case. Pakistan, by trading with comparatively small countries, can enhance transit trade. On the other hand, Pakistan can benefit more while trading with big countries due to comparative small export surplus. The policies of ease of doing business can help industrial growth, and it will also contribute to economic growth. For example, in China, the labor cost is increasing, and manufacturing companies may find it feasible to relocate for more profit.

The trade-offs and competitive factors used are exemplary and can be changed, increased, or decreased as per the needs and gains. Table 2 shows the perceived logical trade-offs considering road trading on the parallel route system of the CPEC. The adopted trade-off variables are found most cited and considered as “important” in road trading when the main goal is to create ease of doing business. The critical trade-off variables are the road transportation cost (C), the transport reliability (R), transport information system (I), capacity (V), and safety services (S). The road transport cost (C) consists of travel time, travel cost, and safety cost. Transport reliability (R) includes speed and routing flexibility. The transportation information systems (I) is meant to be e-commerce and logistical updates, capacity (V) is the volume and variety of trade (that a highway can allow), and transport safety (S) are the probabilities of accidents (fatal and non-fatal), natural disasters (includes temperature, earthquakes, land sidings, etc.), terrorism (man-made insecurities), because these factors effects majorly on the exchange rate and it becomes major obstacle for regional growth (Maitah et al. 2017).

Table 2. Essential factors, route cases trade-offs, and sustainable outcomes.

Important Factors	Western	Central	Eastern	Outcomes
Infrastructure	CV, CI	CV, CI	CV, RV	Integration
Transport services	CR, CV	CR, RV, CV	CR, CV	Cooperation
Logistical technology	CI, RV, RS	CI, RV, RS	CI, RV, RS	Welfare
Policies/regulations	ALL	ALL	ALL	Growth

Note the competitive trade-offs: C = Transportation cost (travel time, operational cost and security cost). R = Transportation reliability (Quality, flexibility, and speed). I = Information systems (ecommerce and logistics). V = Capacity (volume and variety of trade). S = Transport safety (safety from accidents, natural disasters, and terrorism).

The important factors are the result of the investments and policies, which enable the trade-offs to take place at different levels. For instance, in the central case, the construction of the new highway decreased the traveling cost (C) dramatically, but it is still higher than the western route. The construction of the new central route has enabled the trade-offs with a variety of commodities (V) and facilitates the smooth transport process. Moreover, it can accommodate a transport volume (V) with the least transits, but the insecurity rate is high. Hence, the CV (cost and capacity) and CI (cost and information systems) trade-offs can make the central region integrated for smooth operations. Conversely, the eastern case with road infrastructure allows us to increase the reliability (R), due to its pre-established industrial areas, without compromising the capacity of trade (V). Although the infrastructure achieves the RV trade-offs at a higher level, the RV still exists independently of the infrastructure, which allows the balanced volume to ensure transportation safety. On the other hand, CI (cost versus information) trade-offs, in the eastern route, play a more vital role than in the central and western routes. This is since the eastern route is more affected by the terrorism and natural disasters than the central and western routes which has high facilitation rate of social welfare (i.e., insecurity probability 64%). The information system can reduce the cost; however, the better the information system is employed the more cost it may demand.

Similarly, the number of services facilitates the business cooperation with the help of tradeoffs like the CR (cost versus reliability), while logistic technologies bring integrity by enabling tradeoffs like the RS, i.e., to find the trade-off of transport safety (S) and transport reliability (R). Now, we discuss in detail the conceptual design of the trade-off in the next proposition. In many pieces of literature, the trade-offs are mentioned as problems because of their traditional behavior in causing a change to other elements when action is taken to improve one. It is termed in many pieces of literature as “sensitivity”. Whereas, insensitive factors are the one where one competitive achievement can be gained with little change in the other, which we termed here as an “improved trade-off”.

Proposition 9. *The internal variables determining sensitivity.*

The internal variables of transport corridors determine the sensitivity of essential competitive factors. These internal variables include resource, capacity, and attribute. The competitive factors are dependent on the sources of internal variables, i.e., trade specialization and national-international trade policy. Likewise, the parallel route system of the CPEC passes through different provinces with different local government control, and every province, in Pakistan, has different competencies of selected resources, see Table 3.

1. Resources are the available factors owned by an operating authority (Amit and Schoemaker 1993). In our cases, they are the present fertile cultivatable area, production of four major crops (wheat, rice, cotton, and sugarcane), and population density of the western, central, and eastern cases, see Table 3. Please note that the mentioned resources are selected based on regions around the CPEC routes. The total provincial capacity is not taken because our study aims to find out the role of the trade-offs in the road transport routes resourced by the aforementioned factors. It is essential to know why cultivation area, crop production, and population are selected as resources in gaining a competitive edge. For example, the relative elasticity of demand can be improved with the help of trading with competitive agricultural products, which can increase the impact on the CV (cost and variety) trade-off. Whereas, the provincial governments (as in the western case) can accomplish their development objectives by offering their low-cost labor and by improving the trade-off assumption of the RV (reliability and volume). This is possible with an increase in the road segments connecting the deprived areas, as it will save time, money, and improve accessibility. However, making more roads can affect the cultivation areas (which are the assets of a country), so one has to see if it can give vital gains in return and the higher level the RV trade-off.
2. Capacities are the total agricultural production, routing flexibility, and highway capacities in terms of the number of available road lanes. Resources and capacities are equally important to

each other. For example, in the central case, chances of competitive advantage are increased with the help of the trade-offs, enabled by its up-gradation as the shortest highway path. In addition, due to its central location, it has more capacity of route segments to connect with the western and eastern route, which gives a strong trade-off relation among the CR (cost and reliability), the RV (reliability and capacity), and the CV (cost and capacity) to achieve competitive objectives. On the other hand, the eastern case can enhance trade with the big countries by using agricultural expertise and to gain benefits in return, which creates the need to relax the assumption of the RV trade-off (reliability and capacity).

- Attributes are defined as the rerouting flexibility and trading reliability on the central, eastern, and western routes (the parallel route system). The attributes can be improved with the combination of capacities and resources. For example, the central case, due to its central location, can have more routing flexibility due to route segments connected to eastern and western cases, whereas the eastern and western cases will be less flexible with each other during road transportation. Similarly, the reliability also majorly depends on the route safety, Pakistan has been a hub of terrorist attacks which has been improved manifold but not eliminated, see Table A1 in Appendix A. The more the routing reliability can be increased, the more chances there will be to improve the CR in the long run. Another option is to upgrade the roads with more lanes which may pay back sooner or later, but one cannot increase the transport reliability by the existence of road insecurities, since it may increase the permanent indirect cost. In the western case, CR can be positively affected by close coordination between trade policy and route extensions to landlocked countries on its western border. It does not mean that CR will not be positively affected on other routes, but it is rather not a priority need on other routes. In all the cases, it is suggested that the sensitivity of the trade-off, such as RV, can be improved by improving core competency, i.e., production of major crops and delivery flexibility.

Table 3. Internal variables to determine sensitive roles.

Variables	Eastern Route	Central Route	Western Route
Cultivated area (000 ha)	264	156	98
Production ¹ (000 tones)	10,322	5829	2993
Population density (per sq. km of land)	30,928	13,754	7430
Highway capacity (lanes) ²	6	2	4
Routing flexibility (percentage) ³	62	68	43

¹ Production of wheat, rice, cotton, and sugar-cane are considered (Bengali 2015). ² The number of lanes is as per the official record of the National Highway Authority (Highway 2019). ³ Routing flexibility is measured by the average cost and time of each route. See Appendix A.

Figure 4 shows the sensitive role of internal variables (i.e., resource, capacity, and attribute). They are used to improve the pivot of trade-offs and allow one or more pairs to make trade-offs at a higher level to achieve high-level performance.

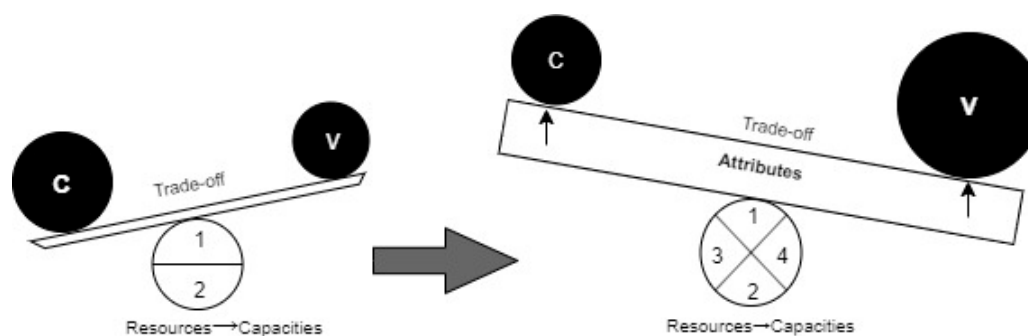


Figure 4. Trade-offs improvement by resources, capacities, and attributes.

6. Conclusions

The particular cases of a transport corridor unfold that the trade-offs are real, and they do exist; even more, they are the central approach for improving the operational processes. The much-argued questions “whether the trade-offs exist or which of them are more real and beneficial”, are directly relevant to operations management practices and hence missing the point here. It is more useful to pose questions “How trade-off factors should be perceived in transport operations for a consistent competitive edge?”, “What are the trade-off factors that can benefit more for specific sub-operations?”, and “How many ways can be adopted to overcome the trade-offs”. This paper does not adequately address these questions; instead, it provides an insight for operational managers in the transport corridors, who handle the process every day. The trade-off method can be an operational management technique, so that decision-makers do not have to invest in infrastructure to improve road reliability and traffic capacity, but can use alternative technologies for intelligent management.

Furthermore, it put forward the most useful ideas, which provide the foundation for the trade-off concept in transport operations, for far-reaching socio-economic benefits. They are as follows:

- Trade-offs are easily adaptable for practicing operational managers.
- The trade-offs, for consistent competitive advantages, are comparatively understandable and straightforward, which foresee the expected compromises for more consistent trade growth.
- Trade-offs must always be seen as a tool towards improvement in operations strategy. Otherwise, we must consider that the trade-offs have been overcome, and there is no room for further trade-offs. At this stage, further investment in resources and capacities may enable the trade-offs again at a higher level of performance.
- Among the corridors’ operations, many sub-operations may find trade-offs as an easier approach than some other operations. For example, the series route system may have less capacity to accommodate trade-offs because of its less re-routing flexibility.
- The recognized trade-offs can be improved or raised using pivot by improving the resources and capacities in the transport corridor, but cannot be eliminated, because it helps to improve the related performance attribute.
- A trade-off in road transport operations differs in two aspects. First is the degree of importance that impacts the operational competitiveness, and the second is the degree of sensitivity that the change in one factor of operation may have a less or more significant effect on the other factors, where the optimal balance among trade-offs play the role.
- In the transportation corridor, some trade-offs are more apparent and strongly governed by recognized resources and capacities than other critical trade-offs.

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Appendix A

The figures and information on CPEC routes have been fetched from the national highway authority of Pakistan and Google maps ([Highway 2019](#)). Calculations are computed using Microsoft Excel.

Table A1. Cost, time, and safety insecurity on city nodes among parallel route system.

Sr	Major City Nodes under CPEC	Time Including Delay Time				Un-Safe Factors Disaster, Accidents, Terrorism			Cost			
		(h)	Prob	Mean	Var	Prob	Mean	Var	(\$)	Prob	Mean	Var
	WESTERN ROUTE	56.29	0.41			0.32			723	0.55		
1	Burhan-D.I.Khan	11	0.34			0.46			125	0.49		
2	D.I.Khan-Zhob	9.4	0.31			0.48			89	0.28		
3	Zhob-Quetta	11.92	0.35			0.42			144	0.6		
4	Quetta-Surab	9.58	0.32	0.34	0	0.41	0.41	0.01	93	0.3	0.46	0.05
5	Surab-Hoshab	14.28	0.39			0.24			194	0.86		
6	Hoshab-Gwadar	9.16	0.31			0.44			84	0.25		
	CENTRAL ROUTE	61.5	0.91			0.11			760	0.6		
1	Burhan-D.I.Khan (Partial Western Route)	11.06	0.34			0.4			125	0.49		
2	D.I.Khan-Jampur	10.3	0.33			0.47			109	0.39		
3	Jampur-Wangu Hills	12.56	0.36			0.49			157	0.68		
4	Wangu Hills-Khuzdar	7.46	0.29	0.34	0	0.22	0.36	0.01	48	0.11	0.46	0.1
5	Khuzdar-Basima	7.5	0.29			0.22			49	0.11		
6	Basima-Gwadar (Partial Western Route)	18.14	0.44			0.33			277	0.99		
	EASTERN ROUTE	112.58	0.41			0.64			948	0.84		
1	Peshawar-Islamabad	50.8	0.88			0.48			112	0.41		
2	Islamabad-Pindi Bhattian	73.6	0.98			0.3			150	0.64		
3	Pindi Bhattian-Multan	106.66	1			0.49			161	0.7		
4	Multan-Sukkur	13.14	0.37	0.69	0.07	0.55	0.52	0.01	176	0.78	0.61	0.06
5	Sukkur-Hyderabad	11.22	0.34			0.55			136	0.56		
6	Hyderabad-Karachi	45.12	0.83			0.63			65	0.17		
7	Karachi-Gwadar	17.9	0.45			0.63			272	0.99		

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