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Reduction of Domestic Air Traffic at Istanbul Airports via High-Speed Rail

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Abstract

Istanbul is the economic driver of Turkey. The city is strategically located on the historic Silk Road, which has allowed the transferring of goods between Europe and Asia for more than 2,000 years. Historically, Istanbul has been a port city for commerce. Today, a significant portion of domestic air traffic in Turkey uses two major routes: Istanbul to Ankara and Istanbul to Izmir. The cities are not far from each other, but the overcrowded traffic on highways causes people to choose to fly between these city pairs, which creates a great deal of congestion at the airports. Therefore, the Ministry of Transport and Infrastructure is looking for new ways to reduce air travel demand, particularly for these two routes. This study examines the possibility of traffic reduction in Istanbul airports by investment in high-speed train technology and its effect on airport operations in Istanbul.

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Keywords: High Speed Train; Istanbul New Airport; Intermodal Transport; Passenger Satisfaction; Rail Infrastructure

1. Introduction

After the deregulation of the transportation market in Turkey, according to Kotil (2016), the aviation sector started to grow and has become one of the most successful industries in the country. As with the aviation sector, the government has continuously supported investment in a high-speed rail system. Turkey’s current geographical conditions allow the country to serve as a global connecting point for European and Asian countries, which is appropriate given that Turkey once acted as a bridge for the ancient Silk Road, stimulating trade between China and

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England. After the completion of all high-speed networks, Turkey will benefit from its geographical location because the train links will energize the former Silk Road connection. According to Daily Sabah Business (2017), “The latest high-speed rail line will connect the Yavuz Sultan Selim Bridge to Istanbul New Airport. It will ease traffic congestion and boost connectivity between Asia and Europe, a priority for the Silk Road project.”

Currently, Istanbul has two commercial airports in the city. The first one, Istanbul Ataturk Airport (IST), is the biggest airport in Turkey by the total number of passengers, destinations served, and the number of aircraft taking off and landing. This airport functions as the central hub for Turkish Airlines, Atlas Global, and Onur Air (TAV, 2018a). According to CAPA (2018), 56 airlines operate at the airport and fly to more than 300 destinations in approximately 110 countries. In 2017, the airport served a total of nearly 63.72 million visitors, and it was the fifth busiest airport in Europe in terms of passenger numbers and the 17th busiest airport worldwide; it has positioned itself as one of the world’s most significant transfer hubs (ACI, 2018). Turkish Airlines dominates seat capacity at IST with almost 75% of all flights.

The other airport located in Istanbul is Sabiha Gokcen Airport (SAW). According to CAPA, Istanbul SAW has grown passenger numbers at an average of 25% per year since 2008, compared with 9% for the larger IST. Primarily a low-cost airport (it is Europe’s fifth biggest for low-cost carrier seats), and the central hub of ultra-low-cost carrier (LCC) Pegasus Airlines, SAW also serves as an overflow base for flagship carrier Turkish Airlines. However, both airports have capacity constraints. After handling 31 million passengers in 2017, SAW already plans to increase its capacity to 63 million by 2020. This airport provides service for 19 airlines.

This article investigates the possible reduction of air traffic in Istanbul in light of the new government investment in high-speed railway connections, beginning with a review of the literature in terms of multimodal transportation. Then, the article provides information about current high-speed rail and aviation infrastructure investments and the pricing strategy for each mode of transportation in Turkey. The new airport section provides detailed project specifications about the third airport construction in Istanbul. In the current railway connection section, there is a discussion of the role of the Turkish railway and airway industries, as well as the Turkish government, in promoting rail transport along the aforementioned flight routes. The route analysis section gives detailed information about current flight operations for each route, and the passenger’s perspective section discusses the possibility of transferring passenger demand in aviation to a new high-speed network, which would improve the time, price, and service quality for both modes of transport.

2. Literature Related to Air-Rail Competition

Several studies have explored the issue of competition between air and rail. Behrens and Pels (2012) analyzed the reactions of passengers and their behaviors upon the withdrawal of aviation alternatives and the completion of the high-speed rail link between London and Paris in November 2007. According to Behrens and Pels (2012), travel time and frequency are the main determinants of travel behavior. These researchers concluded that the direct elasticity of market share for high-speed trains (HSTs) with respect to frequency for a number of aviation alternatives was greater than 1, indicating that even if both modes of transport tried to attract passengers, none of them would be able to maximize profits due to strong competition. Gundelfinger-Casar and Coto-Millán (2017) researched generalized passenger transport costs for Spain’s high-speed rail and domestic passenger flights for the period 2005 to 2014. They revealed that the demand for air travel had fallen due to increased competition from high-speed rail. The summarized findings of the study were that first, if economic activity increased by 1%, air transport demand could be expected to increase by 1.95%. Second, if the implied price of air transport between Madrid and Valencia increased 1%, the demand for air traffic could be expected to drop by 0.83%. And finally, a 1% reduction in rail transport travel time was associated with a 0.38% drop in demand for air travel.

Clewlow et al. (2014) showed that the presence of high-speed rail contributed to lower domestic air passenger traffic in the European market. According to the results obtained from their model, HST rail reduced the intra-European Schengen area air travel demand 48.8%, with significance at the 0.001% level in 35 airports and 90 airport pairs. According to Wang et al. (2017), in the highly populated and developed corridors (population is bigger than 0,5 million and the flight distance is lower than 1000 Km), HST expansion would take all LCC passengers. In their case study of Spring Airlines, Wang et al. (2017) found that Spring was forced to withdraw from all short-haul markets to avoid head-to-head competition with HSTs, and its current network could be squeezed further with the planned HST expansion by 2025. Our analysis of Spring's response to the entry of HST in the market suggests further that one way for LCCs to survive may be to redeploy their capacities to markets and routes of farther distances.

Bilotkach et al. (2010) researched the importance of the distance variable in determining airline strategy by using a database of several European cities. The authors concluded that the shorter the distance (< 475 km), the greater the possibility that air transport would be replaced by rail, which would lead airlines to react strategically by offering increased frequency of flights. The authors calculated the reduction of air travel frequency for specific route distances would be 23% for distances up to 475 km, 15% for distances between 475 and 500 km, 19% for distances between 500 and 525 km, and 18% for distances between 525 and 550 km. On the contrary, Dobruszkes (2011) stated that the flagship carrier airline of Germany, Lufthansa, increased its services after the introduction of the Cologne–Frankfurt railway line. However, it was later forced to reduce its flight frequencies with the inauguration of the HST line between Cologne and Munich, even though this service stops at several stations en route and is not high speed for the entire journey.

According to Crozet (2013), the key elements for a high-speed line are an optimal distance of between 400 and 1000 km and sufficiently large centers of population that justify 15 to 20 round-trip journeys per day. Regarding the pricing strategy, Crozet stated that the French national railway, Société Nationale des Chemins de Fer Français (SNCF), has applied an effective and constantly updated yield management principle. Ticket prices are geared not just to second- or first-class travel and the distance traveled; they vary depending on the destination and the day and time of travel. By establishing a mandatory reservation system for all French HSTs, the Train Grande Vitesse (TGV) services, SNCF has gained a very accurate, real-time insight into the demand for each destination and each train. The development of Internet booking has reinforced this information. Today, when ticket sales become available three months before a train is due to depart, the price may be relatively low (EUR 25 for a second-class ticket between Paris and Lyon). The closer the departure date gets, the more the price goes up (to as much as EUR 80 on peak days). As a result, average train occupancy rates for TGVs are relatively high (nearly 70%), and the capacity of TGV coach sets has gradually increased from 350 to 400 and then to 400 seats in eight coaches. This has been made possible by the development of double-deck coaches. By eliminating the buffet car and by installing second-class seats only, it is possible to have 600 seats per coach set. Since trains can have two sets, it is not uncommon, at peak times, to see 1,000 people getting off a single train. Then it is the stations that are at a saturation point and in need of enlargement. Crozet also stated that it is possible to directly compare the modal split between high-speed rail and air between two cities by comparing the difference in journey time via train and via air. When the journey time is the same, train captures almost the entire market. Once the journey time by rail exceeds the journey time by air by 1 to 2 hours, the market share drops to about 50% and decreases rapidly thereafter (Fig. 1).

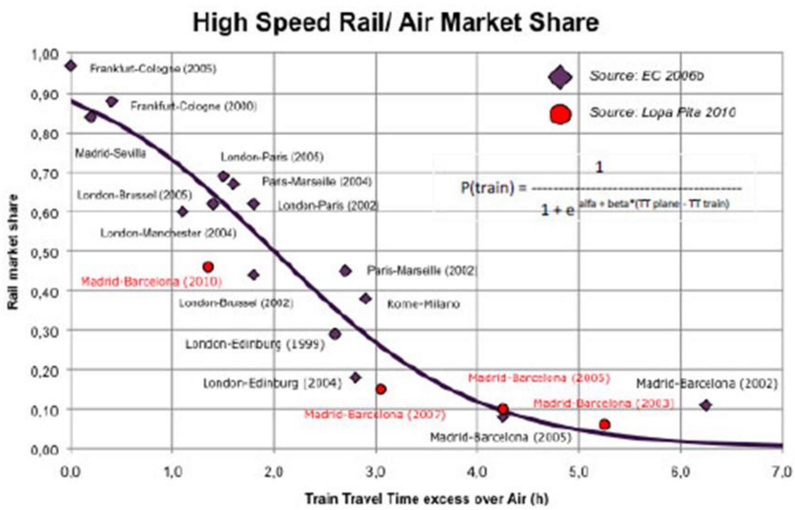

Fig. 1. HST train market share.
Source: European Commission, Air and rail competition and complementarity, 2006.; López Pita, A. et al., High-speed rail modal split on routes with high air traffic density, 2012.

With regard to investment in HST technologies, Campos and de Rus (2009) stated that the structure and cost level of HST investments indicate it is an expensive and risky alternative mode of transport that requires a careful case-by-case socioeconomic appraisal. According to Feuerstein et al. (2018), the factors that have the most impact on open access competition are access to attractive train routes, market potential, the presence of intermodal competitors, low profitability of the industry, and infrastructure costs. However, these factors are not the same for every country in Europe. Chiambaretto et al. (2013) polled passengers at the train station at Charles de Gaulle Airport (CDG) about their willingness to pay for certain intermodal service attributes, and they found that business and leisure travelers have different expectations from HST investments. The business passengers demanded comfortable seating, meal service, and lounge access; however, leisure travelers sought lower fees for the trains.

Concerning service quality in the Turkish HST system, Alpu (2015) researched passengers using services between Eskisehir and Ankara, and the results showed that customers were highly satisfied with the current efforts to provide HST services between other cities and to increase the share of HST services within Turkey's transportation system. Gumus and Gulal (2016) researched the economic impact of building a new HST versus using existing rail infrastructure with some general improvements (repairing existing tracks to meet the latest standards). According to the results, while repairing the existing rail infrastructure would be cheaper, it would not provide the full comfort of HSTs for customers. In order to operate HSTs with comfort, a totally new rail infrastructure is needed in Turkey. Therefore, Turkey needs additional time to complete an HST network with new tracks.

However, when Özgür (2011) compared expectations with the actual outcomes of train investments in Istanbul, Ankara, Izmir, and Bursa, the results showed that rail systems, even high-speed ones, were performing rather poorly in terms of expectations, with passengers noting factors such as the rail systems being incomplete and that they do not want to travel only partially using HSTs then having to use regular coach buses for the remaining distance. Furthermore, it was found that the budget allocated to HST construction is insufficient for completing projects due to the devaluation of the Turkish national currency (TRY) because, while all tickets are sold in TRY, the operating costs are related to the Euro (EUR).

3. New Airport in Istanbul

Istanbul's new airport, the Istanbul Grand Airport (IGA), is being constructed over an area of 76.5 million m² on the European side of Istanbul, 35 kilometers from the city center. The airport is scheduled to open in October 2018 with an initial capacity of 90 million passengers. Once completed, IGA is expected to increase its annual passenger capacity to 150 million by 2023, with a possible increase to 200 million if needed. With flights to more than 350 destinations, the airport will make Istanbul one of the leading global aviation hubs in the world (IGA, 2017).

The opening of Istanbul's new airport in 2018, followed by the phased reduction of operations at IST, which will be closed to commercial passenger traffic, will ease pressure on Istanbul's airport system and give Turkish Airlines a new hub with vast expansion potential. It will also allow SAW to focus on its main role as a low-cost point-to-point airport. IGA will include three independent parallel runways and a terminal building. The first terminal is going to be the biggest terminal under one roof in the world, extending over an area of 1.3 million m². Once totally complete, the airport will have six independent runways, four aprons, 16 taxiways, four domestic and international terminal buildings, three technical blocks, an air traffic control tower at a height of 85 m, and eight apron observation towers (IGA, 2018). One of the unique specifications of this new airport is that it will have a direct connection with HST construction and the intercity rail network via a special train station located inside the compound. A diagram of the airport–city HST rail link is shown in Fig. 2.

Fig. 2. HST train construction in Istanbul.

4. Current Railway Connections in Turkey

Turkey's current HST infrastructure has so far not been extended between Ankara and Istanbul (451 km) and between Ankara and Izmir (470 km). Only some regional trains are operating between these cities, with an average velocity of 80 km/h. However, the capacities of the regional trains are too low to meet the enormous passenger demand. According to Shakibaei and Alpkokin (2017), the Turkish government has taken remarkable steps in developing new HST and conventional lines as well as in improving existing lines since the 2000s, but there is still a long way to go to reach the railway sector goals for 2023, which is the 100th anniversary of the establishment of the Republic of Turkey. For decades, Turkish National Railways (TCDD) has had a monopoly over all sector layers—namely, network infrastructure, infrastructure management, and network services for both passenger and freight networks. TCDD is completely under government control; it both owns the tracks and operates the trains, and all investments are made according to the allocation of government budgets. In this case, deadweight loss, which is a social cost of economic inefficacy, is highly probable due to the lack of a competitive market. Ongoing economic problems have severely constrained the fiscal space in Turkey and have limited public funds for new infrastructure investments. In order to increase the investments with minimal risks, the only option is expansion of infrastructure through public-private partnerships. Moreover, the unique global positioning of Turkey, together with its attempts to join the European Union, necessitate the acceleration of the privatization of rail investments. According to the National Budget Control Institution of Turkey (SAYISTAY, 2018), TCDD has not earned a single dollar from its operations for a long period of time (150 years), yet it demands more government support in each new budget period. New government plans, however, involve TCDD owning the tracks but having private companies handle the train operations.

In order to increase the availability of rail transport between Ankara and Istanbul, the government has initiated two different HST projects. The first project is a rail link between Ankara and Istanbul via Eskisehir Province. The first phase of the project, Ankara to Eskisehir, is fully operational, but the second phase, Eskisehir to Istanbul, is still under construction. After completion of the project, trains will be able to travel between Ankara and Istanbul in 3 hours.

According to the Ministry of Infrastructure and Transport of Turkey, the second project includes an ultra-HST, which can cruise at a maximum of 350 km/h (RailNews, 2017). With this new technology, the total travel time between Ankara and Istanbul will be reduced to only 1 hour and 45 minutes. This infrastructure investment is too expensive for the government; thus, the government decided to invest in this project with a build–operate–transfer business model. The same ownership model will build the train link between Izmir and Istanbul. The projected travel time between Istanbul and Izmir is 1 hour and 30 minutes.

5. Route Analysis Regarding Rail-Air Connection

Capacity problems constitute an explicit restriction on the growth of airlines operating at IST, which creates a critical problem for transportation in the city. Today, IST can no longer meet the demand of airlines, and new slots are unavailable for additional flights and newcomers. SAW has started to face the same situation recently as its primary operator, Pegasus Airlines, keeps launching new flights to more destinations and increasing frequencies on existing routes from its SAW hub. Moreover, Turkish Airlines has increased its capacity at SAW with its subsidiary airline AnadoluJet. Both of the airports located in Istanbul have reached their maximum capacity, and delays have become unavoidable, especially during peak times. Recent 2017 data have revealed that IST and SAW experience the greatest number of delays when compared to other European hubs (OAG, 2018). According to OAG, 73.86% of the planes arrive or depart within a 15-minute time frame of the original schedule at IST. However, this number is 74.8% at London Heathrow, 76.35% at Frankfurt Airport, and 77.09% at Amsterdam Schiphol airport. These airports have extensive international route structures, and they are the hubs for the national flagship carriers of their home countries. Each of the airports belongs to the worldwide airline alliances hub network, and each is served by local rail networks. Thus, it can be assumed that linking the IST and SAW airports with rail would eventually increase the on-time performance of flight arrivals and departures because of the decrease in air traffic.

The majority of the capacity problems are related to domestic departures between IST and SAW to Izmir and Ankara airports. According to CAPA (2018) statistics, the average number of weekly departures from IST and SAW to Ankara is 468, while the average number of weekly departures from IST and SAW to Izmir is 428. This means that, according to these numbers, a plane departs these airports every 12 minutes, which causes significant traffic both in airspace and for airport ground operations.

Currently, to serve these city pairs, TCDD is beginning production of Siemens Velaro HST trains in Turkey via a joint venture partnership with Siemens. This train has a maximum speed of 300 km/h. According to Siemens, the Velaro train has a 591-passenger seat capacity, of which 45 are business class seats. These trains are currently operational between Ankara and Konya and between Ankara and Eskisehir Province. The tickets for these trains are always sold out before the departure due to the high levels of passenger satisfaction. The current map of Siemens Velaro train routes is shown in Fig. 3.

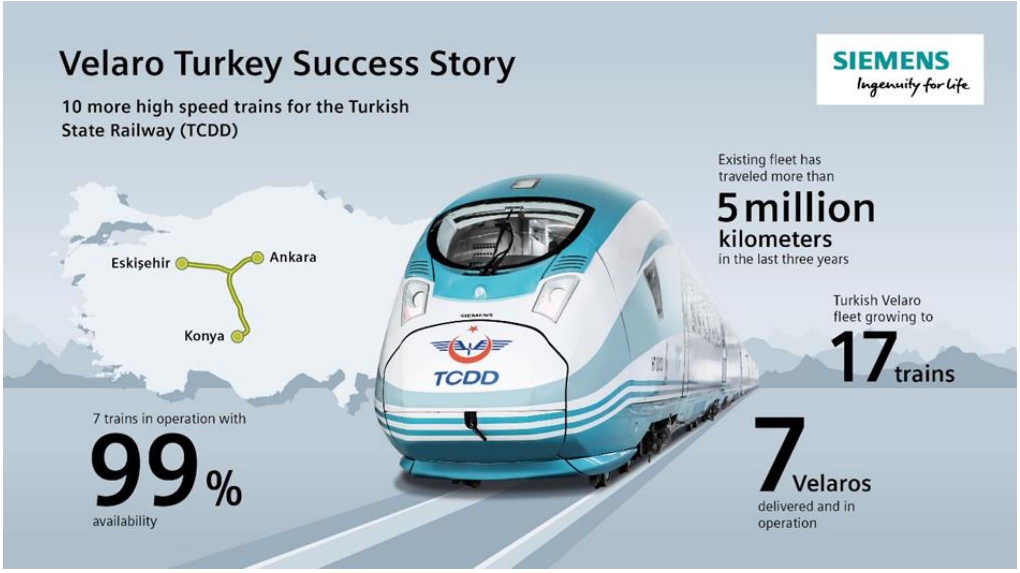

Fig. 3: Siemens Velaro train.

The unique structure of the Siemens Velaro train allows it to carry approximately the same number of passengers as three Boeing 737 planes. The management of TCDD tries to schedule these trains so that they depart every hour. Thus, using this train on an hourly departure schedule creates more than enough capacity to carry all domestic passengers for both the Ankara to Istanbul and the Ankara to Izmir routes. The total travel time between Ankara or Izmir to Istanbul will be 3 hours, and both of the rail systems are under construction now. If the government decides to privatize an ultra-high-speed project between these city pairs with additional railroad capacity, the total travel time will be reduced to less than 2 hours for either route.

According to the Ankara Metropolitan Municipality Airport (2018) and the Izmir Metropolitan Municipality Airport (2018), the current travel time to airports in Ankara and Izmir is about 45 minutes with direct transit connections from the city centers. The minimum check-in deadline for airlines for Turkish domestic routes is 1 hour before departure. The average flight time (gate to gate) is approximately 1 hour and 30 minutes for Ankara or Izmir to Istanbul (Turkish Airlines, 2018). The real flight time is 45 minutes. But because of the vast amount of traffic in Istanbul, it takes an additional 45 minutes for planes to reach the runway or gate (TAV Istanbul Airport, 2018b). According to Istanbul Metropolitan Municipality (2018), the total travel time from Istanbul airports to the city center of Taksim Square is at least 2 hours regardless of which airport passengers arrive at. Thus, the minimum time spent traveling between Ankara or Izmir to Istanbul's city center is 5 hours and 15 minutes.

According to this calculation, traveling by HST would enable passengers to save at least 2 hours and 15 minutes of travel time for the highlighted routes. The total reduction in travel time is generally because planes have delays due to weather. The most important specification of HSTs in Turkey is that the trains depart directly from the city center, with local metro connections. No matter what happens, the HST train trip will be more rapid than domestic air service once construction is completed.

The TCDD Railway Market Report (2017) provides an HST passenger transport ratio giving the percentage of passengers taking HST trains compared to air transportation. The HST passenger transport ratio for existing railways between Ankara to Eskisehir is shown in Fig. 4.

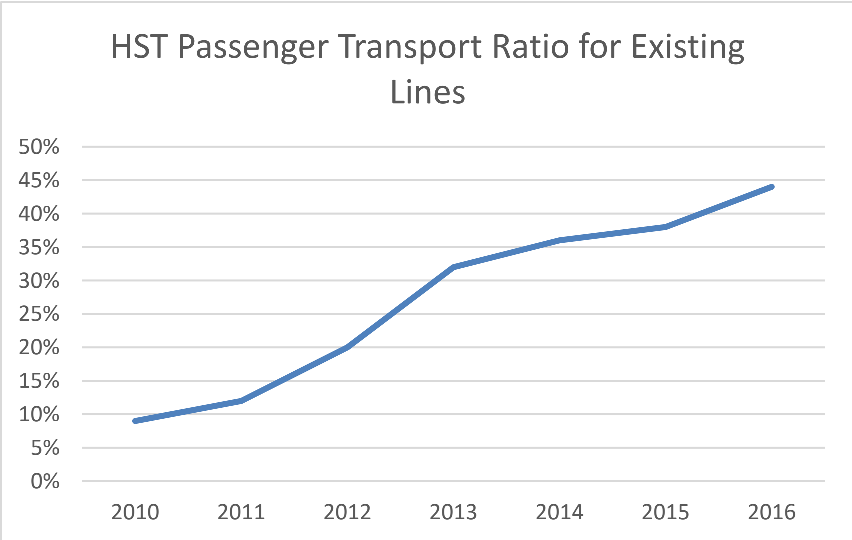

Fig. 4. HST passenger transport ratio for existing lines.

According to the market report (TCDD, 2017), The HST passenger transport ratio is 100% correlated with the acquisition of new train wagon sets. Because the price, demand for trains, and train load factors are constant due to the reasons described in Section 6, the load factor has been constant at 100% for the past 6 years of operations, and HST trains start overtaking passenger demand by 5% upon arrival of new train sets for the Ankara, Eskisehir, and Konya routes. Currently, TCDD has 11 wagon sets that capture the point-to-point passenger traffic at the 44% level. The TCDD Railway Market Report (2017) ranking of Turkey for HST passenger ratio in 2016 is shown in Fig. 5.

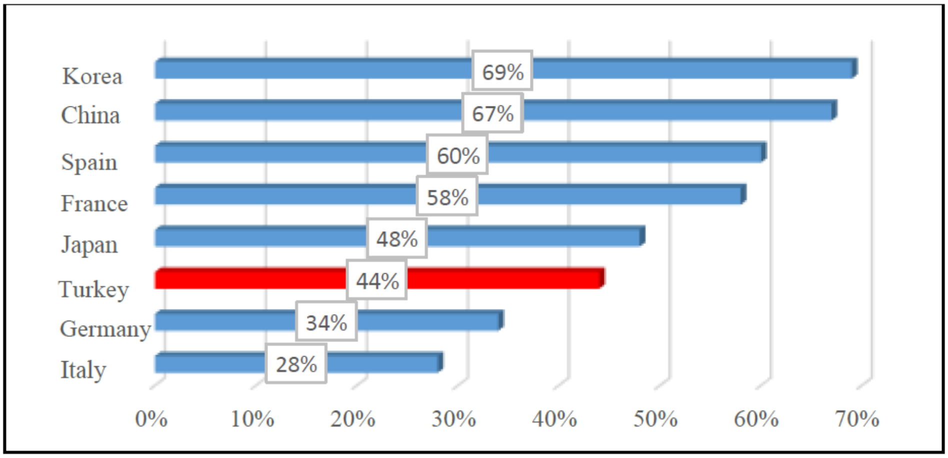

Fig. 5. Ranking of Turkey HST ratio in 2016.

In terms of the ratios shown in Fig. 4 and Fig. 5, HST technology took approximately half of its passengers from other modes of transportation. Therefore, we can conclude that the pricing and marketing strategy of HST lines were successful over those previous years.

The current investment strategy of TCDD is stated in the Ministry of Transportation of Turkey 2023 National Strategic Plan (2018). According to this investment plan, the expansion of the HST system between Istanbul and the Ankara and Izmir provinces will be completed during the first quarter of 2019. After beginning operations, the domestic passenger transport ratio of HST to air travel between our selected routes will be assumed to become 90% in 2023. The methodology used in this report is not based on mathematical models similar to what the authors used to predict passenger demand in Europe and China and is, instead, strictly related to the acquisition of new wagon sets; this is because the demand and load factors of the trains are inelastic at the 100% level. Therefore, we cannot run any mathematical algorithm for TCDD HST operations to Istanbul. The proximate HST ratios for the Istanbul to Ankara and Izmir routes assumption is given in Fig. 6.

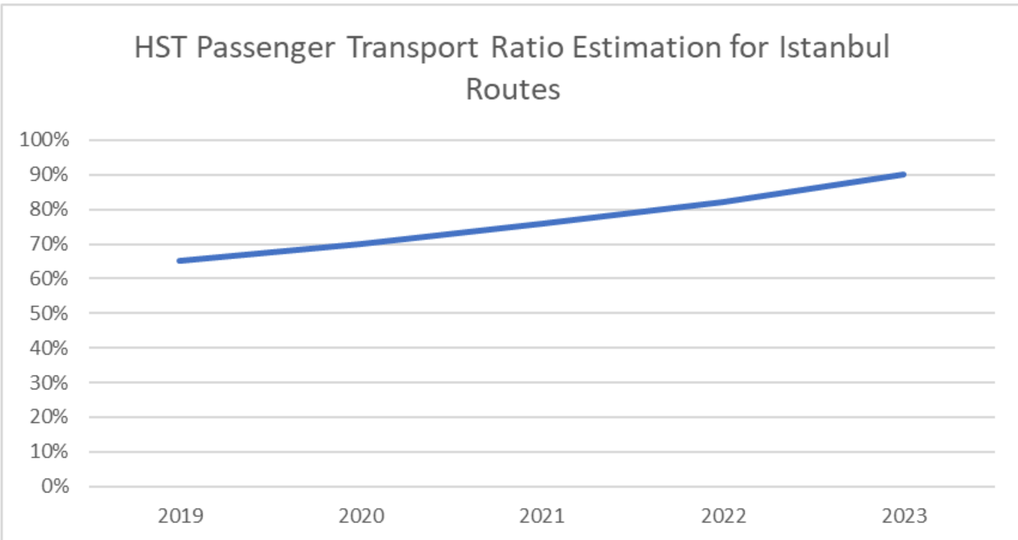

Fig. 6. HST ratios for Istanbul to Ankara and Izmir routes assumptions.

The Ministry of Transportation of Turkey 2023 National Strategic Plan (2018) also states that after 2023, the ultra-HST project will start servicing between our selected routes, and at that time, it is expected that both train services (HST and ultra-HST) will be able to reduce the total domestic air traffic at the 90% level. According to the plan, the remaining 10% for passenger planes must be kept operational to address the demand for transfer passengers and cargo.

By the opening of the ultra-HST project, 15 Siemens wagon sets produced in Turkey via the joint venture program will be operational. In the following years, five more trains will be put into service. These 20 trains will have 10% Turkey-produced parts. In the second phase of the train manufacturing process, 60 HST trains will be produced with 53% Turkey-produced parts, and in the last phase of the manufacturing process, 16 trains will be produced using 74% Turkey-produced parts. The total of 96 trains will be operational on the Istanbul to Ankara and Izmir routes. The main aim of the government is to have a train running every 20 minutes along the mentioned routes via extensive nationally produced wagons.

Regarding the Crozet (2013) report, the HST project takes all air passenger demand if the train routes provide the same travel period. In the case of the IST airport example, the HST project reduces travel time by almost half. Therefore, the 2023 strategic plan targets are not overestimated in the aim of 90% reduction of air traffic, and it is a logical and achievable target.

6. Passengers’ Perspective

According to Behrens and Pels (2012) and Alpu (2015), the total travel time, trip cost, and quality of service are significant factors affecting passenger choice between air and rail transportation. For the total travel time, as mentioned in the previous section, traveling by HST provides more of a time saver than traveling by regular air service.

Additionally, air service quality depends on the type of transport company. Some of the routes are served by full-service carriers, and some of them are serviced by LCCs. The full-cost carriers provide baggage handling plus food and beverage services, whereas LCCs do not give offer anything other than the seat in the aircraft. With HST, customers can choose between different services at different prices. For no more than 30 USD, passengers can travel in business class, with meals and beverages included. For just 10 USD, passengers can travel in the economy wagon, but without a meal. However, every train has an exclusive restaurant-buffet wagon where passengers can enjoy a variety of meals for a reasonable prince (TCDD, 2018).

With regard to pricing strategies, the lowest price for an air ticket to Istanbul from Ankara or Izmir is around 15 USD, including taxes, from LCC Pegasus Airlines (2018). The price of a business class flight is more than 100 USD. Thus, regardless of which class an HST passenger prefers, they will be able to save money versus air transport. Furthermore, if passengers choose to travel by air, they need to spend extra money for the city to airport transfers. Sometimes, the city transfer rates are more expensive than the air tickets, especially in Istanbul. Private charters cost 80 USD in Istanbul, whereas the air ticket is just 15 USD (TAV Airport, 2018c). Regardless of the route, choosing rail transport will be more economical for business and economy passengers. Moreover, baggage is completely free on trains.

Pursuant to Turkish Presidential Legislation No. 1219 (2017), all HST services must be operated using a pricing strategy that is always below the minimum price of airline operations for the same route, and the prices of HST services that are operated by TCDD are standard for each class. These prices are renewed according to annual inflation rates. The main reason for this structure is that, according to the National Statistics Institution of Turkey (2018), 70% of employees in Turkey receive only a 283.33 USD minimum monthly salary regardless of working hours, and 25% of the educated population, including university professors and government advisors, receive only 1.166 USD per month at the maximum level. Therefore, if the government were to adopt a high pricing strategy for the HST trains that are mentioned in Fig. 7, 95% of potential passengers could not afford to travel. The price of Turkish HSTs is 0.017 Euros/km (the lowest in the EU).

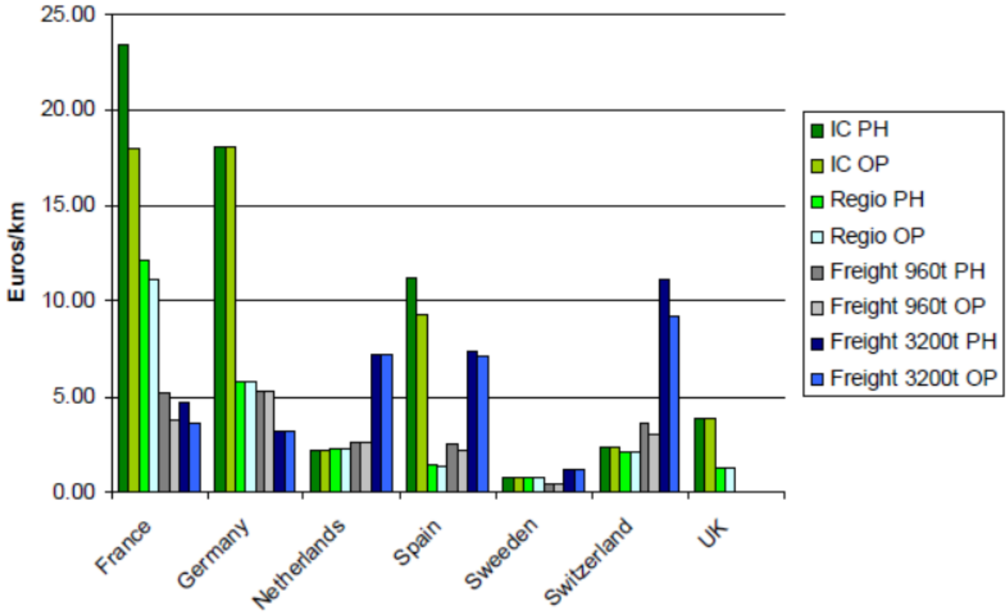

Fig. 7. HST prices in EU countries.
Note: For each country, the two columns on the left indicate high-speed train charges (IC PH and IC OP).
Source: Vidaud and de Tilière, 2010.

The Turkish government policy is to support rail travel because all three of the mentioned cities suffer from serious traffic problems. Even if the plane passengers arrive on is on time, they cannot reach their final destination easily. The Ministry of Infrastructure and Transportation of Turkey (2018) says that the long-term support of HST investments produces more positive income than other modes of transportation because no fuel is needed for transport to/from airports, during the flight, or in intracity traffic congestions because the HSTs are powered with hydro energy and wind power. However, the Ministry fails to show how they performed their calculations regarding these benefits.

Regarding passenger satisfaction, Kılıclar et al. (2010) studied the reasons why passengers select HST services through a questionnaire conducted on HST trains. The results indicate this choice is because HST trains offer faster service, more comfortable seats, cheaper dining options, and free baggage services in all classes of travel for lower fares than all other modes of transportation. According to the National Statistics Institution of Turkey's transport mode satisfaction index (2017), passenger satisfaction with airlines was 63%; conversely, satisfaction with HSTs was at the 99% level. The reduction of 1% was related to the no animals policy on trains.

With regard to drawing a comparison for the Turkish HST system with the Frankfurt–Cologne HST replacement of air services, it is not wrong to estimate that the HST lines from Istanbul to Ankara and Izmir can replace all air services because the price for the HST is kept constantly low, the satisfaction of passengers is significantly higher than air travel, and the total travel time is significantly reduced using HST.

7. Conclusion

In this article, we have discussed the HST investment strategy of the Turkish government according to the various effects of HST on air and rail competition covered in a review of the literature. Currently, domestic air traffic at both Istanbul airports suffers from significant delays and dissatisfaction among customers. It takes a minimum of 5 hours and 15 minutes to travel to Istanbul's city center from either Ankara or Izmir, and as a result, domestic air transportation for those routes does not provide excellent service or customer satisfaction.

In order to solve the high-speed transport problems for those routes, the Turkish government implemented two separate HST construction projects. While the budget planning has been difficult for the government due to more than ten budget revisions since the declaration of the projects, the presidential office is using every available fund to complete both in the short term. According to the literature review, significant factors in air–rail competition are price and customer satisfaction, both of which can be covered by Siemens HST technology. For pricing, the vast passenger capacity of the trains significantly helps to reduce the total cost. Only one train service per hour is more than enough to carry all passengers at reduced fares—as low as 10 USD for a single journey (TCDD, 2018). Furthermore, legislation limits the prices of HST operations due to government support of rail travel. As for passenger satisfaction, Siemens HST trains have different classes of service that include onboard dining, entertainment, and lounge access in selected destinations. Furthermore, no additional transport is required to reach the city centers. According to the literature review, Turkish customers are pleased with this service quality.

Also found in the literature review was that Turkey's HST investment is more than enough to reduce the number of flights between Istanbul and the Izmir and Ankara provinces. Factors in favor of HST include the fact that HST trains are more eco-friendly and cheaper to operate; moreover, the passenger satisfaction rate is higher than with LCC carriers. The unique design of Istanbul's third airport enables these trains to stop directly at the international terminal, and with HST technology, many cities can be connected by point-to-point links. Many neighboring cities will be able to use these train lines as well.

With the proposed privatization of ultra-HST, train travel time will be cut in half, and while but the price will go up, it will still be below LCC carrier rates. The extra costs would be due to expensive investments in security protocols; in order to attract foreign investment in ultra-HST, the Turkish government is offering Treasury guarantees to compensate for losses in transportation investments.

According to the 2023 investment plan of the Ministry of Transportation (2018), approximately 90% of 900 weekly flights will no longer need to be operated if both the HST and ultra-HST train systems start simultaneous operations in 2023, which will create additional capacity for more profitable international flights. The preliminary reduction of air travel service after the introduction of the Frankfurt–Cologne HST proves that the investment plan predictions in Turkey are accurate.

Interestingly, the main reason a new mathematical model similar to the studies mentioned in the literature review section cannot be run regarding passenger demand, pricing, or cabin class configuration of trains is that the demand for HST travel in Turkey is inelastic and, thanks to the low pricing strategy, static at the 100% level, keeping all these variables constant. As long as the fares for travel on these trains remain lower than all other modes of transportation and the quality of service remains the same, the demand will continue to be at extraordinarily high levels. Even if the government loses money in stimulating demand, the long-term benefits of HST in terms of environmental impacts is enough to justify the investment (Dalkic et al. 2017). The value of reduced travel time for passengers provides another valid reason for the government to support HST projects. Moreover, the public will have a less stressful and more comfortable journey for a highly reasonable price.

8. Further Research Opportunities

In this article, a comparison of the literature with the government's project proposals proves that it is possible to reduce the air traffic at Istanbul's airports through investments in HSTs. The HST projects discussed in the literature review revealed that HST technology decreases or completely takes over airline traffic on particular routes. In this paper, we revealed that 90% of the flights could be rendered obsolete when both types of HST trains start operations, but we do not know the passenger choice model between HST and ultra-HST trains. In a further study, we can investigate if it is possible to use a dynamic pricing algorithm in the marketing of ultra-HST trains to compete with HST trains. If we can use such an algorithm, ordinary HST passengers traveling for leisure purposes will be able to move cheaper than the regular price on ultra-HST trains.

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