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THE IMPACT OF DIGITALIZATION AND INTELLIGENTIZATION ON AIR TRANSPORTATION SYSTEM

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Abstract. This study aims to provide insights into the impact levels of digitalization and intelligentization on air transport system (ATS) in Australia, China, the US, and India. Air transport system is one of the most efficient transport systems which contains three elements: air traffic control, airport, and airlines. In modern society, the importance of digitalization and intelligentization in ATS is attached to by publics. In this study, firstly, comparative analysis is used to analyze the different states of digitalization and intelligentization level and air transport system in sample countries. Then, correlation analysis is used to study the correlation of the different impact factors with the ATS in different countries. The third one is regression analysis, it is used to analyze the relationship between ATS and the development of digitalization and intelligentization in four sample countries. At last, forecasting analysis is used to predict the future trend of digitalization and intelligentization's impact on ATS in the sample countries in the next few years. Then, the most significant impact factors for ATS will be obtained. Also, the future development trends of ATS under digitalization and intelligentization's impact could be forecasted by using econometric models.

Keywords: Air Transport System (ATS), digitalization, intelligentization, econometric models, digital impact, digital technology, safety.

Introduction

Air transport system (ATS) is one of the most important infrastructure systems in modern society, and its high efficiency makes publics more convenient. There are three main elements in ATS: air traffic control (ATC), airport, and airline. Except for these main components, human factor, political factor, regulation factor, economic factor, environmental factor, and technological factor are also some important factors that drive the development of ATS (Bieger & Wittmer, 2006).

The capacity and ability of ATS need to be constantly enhanced to satisfy the increasing demand for air transportation. As the transport network becomes more complex, the compatibility of ATS and other transport systems needs to be improved (Zanin & Lillo, 2013). Many innovated technics are used to help the ATS get higher performance. The emergence of e-commerce, such as e-ticketing and e-booking, enables airlines and customers to reach win-win (Jarach, 2002). Since digitalization and intelligentization play a vital role in improving the efficiency of ATS, the research of the influence of digitalization and intelligentization on ATS is significant.

Due to the rapid growth of the global population and economy in the past decade, the development of ATS in this period is very significant. Therefore, this paper will focus on the analysis of the impact of digitalization and intelligentization on ATS in the past ten years. In this paper, India and China are two of the most populous countries, while the US and Australia are two powerful economies (Jarach, 2002). Among them, China has been thought as the fastest growing economy in the world (Shirk, 2007). The development of technology in this country started late, however, it grows fast. As a country with a large population in Asia, India is also developing rapidly in technology (Vaidyanathan, 2008). However, India's technological level is still much lower than that of developed countries and China (IMD World Competitiveness Center, 2019). Therefore, the impact of this low-level development on the air transport industry is worth to study. As early as 1985, the US had paid attention to the technology impact on air transportation (National Research Council, 1985). As the world's largest economy, the US has always kept at a leader position (World Bank, 2020). Besides, air transportation started

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very early in the US, it is worth to analyze the digital impact on such a developed country. The population of Australia is dozens of times smaller than that of the US (World Bank, 2020). However, Australia's technological level is also one of the leading in the world (IMD World Competitiveness Center, 2019). Therefore, for a country which has sparsely populated and advanced technology, it is meaningful to investigate the impact of digitization on the Australian aviation industry. In general, the purpose of this article is to study whether digitalization and intelligentization will have the same impact on air transportation in countries with different development levels.

1. Literature review

1.1. Digitalization and intelligentization

Digitalization could be explained as using different digital technologies to change all aspects of people's surroundings (Gray & Rumpe, 2015; Brennen & Kreiss, 2016). Besides, Lenka et al. (2017) believed that digitalization enables industries and firms to change their strategy and performance. Thus, digitalization can be thought as changing people's lives and industries' operations by using digital technologies. As a concept always be mentioned together with digitalization, intelligentization can be defined as using intelligent decisions to realize innovation and breakthrough under a deep informatization environment (Li, 2020). Hai (2020) thought that intelligentization is using computers to do human works. Thus, intelligentization can be defined as using smart technologies instead of human in works.

As a popular topic in recent years, digitalization is gradually affecting all aspects of people's lives. Besides, business models in all industry markets become more efficient by applying digital technics. Based on this situation, several job opportunities are created and the profits in markets are increasing (Gray & Rumpe, 2015). For example, the use of e-commerce made all business services more efficient (Hagberg et al., 2016). Actually, the core of digitalization is not limited to data. It needs to be modeled by analyzing and summarizing its characteristics, and then the obtained modes of digitalization will be used to resolve further requirements in various fields. However, at the present stage, the accuracy of these digital modes is affected by the quality of data in the database. Besides, due to the constant changes in standards, the development of digitalization requires more efforts and inputs (Gray & Rumpe, 2015).

Since 2008, more and more developed countries have focused on the industrial economies. The governments support to innovate some new product modes to meet the market requirements. Digitalization and intelligentization are applied to upgrade all kind of transport equipment and to enhance the industry competitiveness. For example, digitalization and intelligentization are used in improving aircraft engines, control systems and other important parts (Zhou, 2013).

At present, different countries have applied high technologies to improve the communication and management in ATS (Tang et al., 2018). The application of digitalization and intelligentization in ATS helps to ensure the security and confidentiality of the system. As Zhou mentioned in 2013, digitalization and intelligentization play a significant role in the aviation information system. This kind of information system is effective at tracking targets, and then feeding back to the ATS (Riedl et al., 2017). All in all, the combination of advanced technologies and ATS can ensure the transportation safety and also can maximize the system efficiency.

1.2. Key elements of digitalization and intelligentization in air transportation system (ATS)

Air traffic control, airport, and airline are three major elements that contributed to the ATS (Janic, 2014). In order to enhance the overall performance of ATS, digitalization and intelligentization are applied in these three elements.

Digitalization and intelligentization play a vital role in air traffic control. Information exchange between the pilots and controllers is very important, and the core of this is digital technology (Farley et al., 2000). Real scenario information which shared between the aircraft and ground can be used as basic resource to make reasonable control measures (Farley et al., 2000). However, in this process, a large amount of shared information will inevitably contain some useless data, and filtering this data will cause a large workload to the data processor. Besides, when pilots could obtain as much information as controllers, the pilots may be more likely to trust their own decisions than follow the instructions of towers (Farley et al., 2000). In this situation, negative impacts need to be reduced by applying more improved digital technics like the cyber-physical system framework (Sampigethaya & Poovendran, 2012). All in all, the efficient connection between the aircraft and ground is dependent on the application of digital and intelligent technics.

With the large increase in air traffic, publics also attach importance to the application of digitalization and intelligentization in airports. Runway incursion prevention system (RIPS) and other new technics are adopted to guide pilots and controllers about how to prevent runway accidents (Jones et al., 2001). Another important application of digitalization and intelligentization in airports is automatic border control, which called e-gate. Facial recognition and other e-techniques are used to detect and control passengers' entering and departing. Their facial features and passport information will be recorded and transmitted to the database for comparison (Inoue et al., 2013). This technic improves the working efficiency in airports and also reduces the waiting time of passengers. Therefore, the development of digitalization and intelligentization has positive impacts on airports.

Generally, the digital products that customers could access directly are some e-commerce products of airlines.

From e-trade to online service, all these products use digital and intelligence technologies. For example, online ticket sales is a very popular digital product. It provides a more convenient channel for customers to purchase their tickets. Moreover, the dynamic pricing of the ticket makes it easier for airlines to adjust the ticket price according to passengers' trends (Weiss & Mehrotra, 2001). Thus, these products improve the efficiency of airlines' e-commerce.

1.3. Value

This paper provides information that could help to control the labor cost and maximize the profits. With the development of technologies, more and more digital and intelligence applications in ATS will replace manual labor. Thus, the results provided in the paper could help airlines and airports to balance the labor cost and improvement cost. The sample countries chosen in this study cover both developed and developing countries. In these sample countries, their location, policy, and culture are all different. Thus, the results in this paper can best represent the impact of digitalization and intelligentization in different countries. The differences and similarities of the four sample countries are listed in Table 1 to support the research background. All information and resource used in this table are sourced from World Bank 2020 and national governments' websites. There are two most significant similarities in these four countries: all these sample countries have started their technology innovation and all these four countries are the world's large economies which ranked very high. All in all, the clear and meaningful results of this research could help the aviation industry to attract more investors and some new jobs could be created accordingly. The result also shows which parts of ATS are most affected by digitalization and intelligentization.

2. Methodology

2.1. Data resource

There are three main sources for this paper to obtain secondary data: World Bank, international organization's websites, and national aviation reports. If more data is required in the analysis stage, the source will be listed later.

2.2. Methods

Four methodologies are applied to analyze how digitalization and intelligentization impact on ATS in sample countries.

Firstly, comparative analysis is a method used to compare each case with related data and the nature of these cases. In the 1980s, this concept was first proposed by Charles Ragin, and in the following decades, the comparative analysis method has been improved continually (Rihoux, 2006). It allows the complex analysis to be produced among interrelated and massive amount of information (Ragin, 2014). Comparative analysis has five main elements: selection of comparison cases; measurement; linkage and gap in knowledge; failed data and cases; time dimension; and selection of other relative methods (Rihoux, 2006). Based on the elements, the following are three key steps for applying this method. Firstly, the objective of the investigation needs to be established. Then, listing and plot the data obtained. At last, analyzing and making a conclusion according to the Figures 1–3. In this paper, comparative analysis will be used to analyze the different states of digitalization level and air transport system in Australia, the US, China, and India.

Secondly, correlation analysis is a statistical method that studies the correlation of more than two sets of variables. Currently, correlation analysis is widely used. For example, Tosepu et al. (2020) had used correlation analysis to study if the pandemic of Covid-19 correlated with

Table 1. The similarities and differences in the four sample countries

Element	The US	Australia	China	India
Continents	North America	Oceania	Asia	Asia
Population (2019)	328.240 million	25.364 million	1.398 billion	1.366 billion
GDP (2019)	US$ 21,374,418.88 million	US$ 1,392,680.59 million	US$ 14,342,902.84 million	US$ 2,875,142.31 million
Digital competitive ranking (2019)	1	14	22	44
Developing country or developed country	developed	developed	developing	developing
If start technology innovation	Yes	Yes	Yes	Yes
World Economic Ranking (2020)	1	14	2	7
Number of passenger in Airport (FY2019)	1.05 billion	0.163 billion	1.35 billion	0.344 billion

climate indicators. Besides, Yin and colleagues (2020) had chosen this method to analyze if forming quality correlated with spatter dynamics in laser powder bed fusion. In this paper, correlation analysis is used to study the correlation of the different impact factors with the ATS in different countries.

Thirdly, regression analysis is a statistical method that explores the functional relationship among variables. This method uses an equation model to express the effect of couples of independent variables on a dependent variable (Chatterjee & Hadi, 2015). Regression analysis can be used to simulate the copayment's effect on dental visits, epidemic outbreak predictions in a country, and many other areas (Cooray et al., 2020; Pandey et al., 2020). In this paper, regression analysis will be used to analyze the relationship between national ATS with the development of digitalization and intelligentization.

The last but not the least, forecasting analysis is used to predict the future trend of the objectives based on the historical data and the present data. It usually uses the functional relationship model obtained from regression analysis to make further forecasting (W. Zhang & X. Zhang, 2007). As one of the most widely used analytical methods, forecasting analysis can be used in the study areas of agriculture, economics, environment, and many other areas (W. Zhang & W. Zhang, 2007; Barniv & Myring, 2006; Shi et al., 2001). In this paper, the forecasting analysis will be used to predict the future trend of digitalization and intelligentization's impact on ATS in the sample countries in the next few years.

3. Results

3.1. Comparative results, correlation results, and regression results

In this part, the relationship between the development of air transportation with digitalization and intelligentization will be identified. The population, economic level, location, and technological development of the sample countries are all different, and these factors will impact on the performance of the national air transport industry. Thus, it should be investigated that if countries which have good performance in air transportation will also have a high level of digitalization? The indicator of passenger carried by air is used to identify the development of the air transport industry in countries, and the indicators of high-tech export and digital comparativeness ranking are used to analyze the level of digitalization and intelligentization in these countries. Finally, how digitalization and intelligentization have affected the development and performance of ATS in different countries will be compared and analyzed.

Firstly, the result of comparative analysis will be presented. In this step, passenger carried, digital rank, high-tech export and other digital and intelligent factors are selected as the indicators to measure the impact of digitalization and intelligentization on ATS in four sample countries. The results and analysis are showed as follow.

According to Figure 1, the number of air transport passengers carried is increasing year by year in the four sample countries. Among them, the US keeps at the leading position, which is due to its highly developed economy and aviation industry. The number of air transport passengers carried increases fastest in China, while it increases slowest in Australia. In China, the number of air transport passengers carried in 2008 is 3 times higher than it in 2017. Besides, it can be seen from the Figure 1, the aviation industry in China is developing most rapidly and the Australian aviation industry is stable. Although India is one of the most populous countries, the trend of air transport passengers carried in India is similar with Australia. Besides, as a developed country, the increasing number of passengers carried by air in Australia is not obvious. The unobvious comparison result in Australia is because the population number in Australia is about 40 times less than in other countries (World Bank, 2020). If this difference can be taken into account, the aviation industry in Australia has also developed in a positive way. Comparing between the situations in the US and India, the number of air transport passengers carried in the US is 7 times more than it in India.

Figure 2 shows the data about the high-tech export situation in four sample countries. Unlike the situation shown in Figure 1, China occupies the leading position in this figure. Although there are some fluctuations, the amount of high-tech export in China still presents an

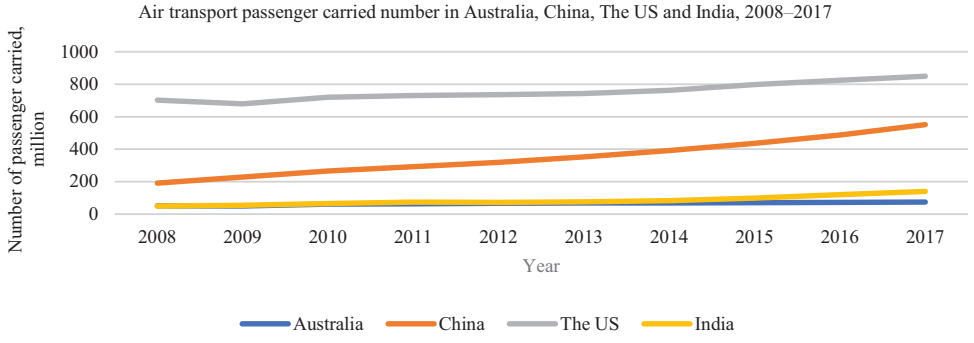

Figure 1. Air transport passenger carried number in Australia, China, The US and India from 2008 to 2017, number in million

upward trend. Different from the situation in China, the amount of high-tech export in the US is decreasing. From 2008 to 2017, the trend of the high-tech export amount in the US had decreased twice. The trends of data in Australia and India are similar which are close to unchanged. Besides, the amounts of high-tech export in these two countries are the lowest in the sample countries. In 2017, the amount of high-tech export in China is more than 6 times than it in India and Australia.

Figure 3 shows the trend of digital ranking level in the four sample countries within 5 years. There are no obvious changes in the levels of digital ranking in four sample countries in recent year. According to the figure, the digital ranking level of the US has always been the highest and at the leading position worldwide. Australia followed the US and occupied the second place in these four countries. Although China ranks as the third one in the figure, the trend of its digital ranking is rising year by year. However, the level of India's digital ranking is in a backward position without an upward trend. This situation means that the development of India's digital technology is slow in recent years.

Table 2 is about the use of high-tech in the sample countries until 2018. All indicators, scores, and data are sourced from Digital airline score (DAS) (SkaiBlu, 2018).

The degree of apply high-tech on ATS is different in these countries. Biometric technology is mainly used in e-passport and smart gate. fingerprint recognition, pupil recognition and facial recognition technologies have significantly improved the efficiency of ATS (Wayman et al., 2005). Moreover, the application of artificially intelligent (AI) chatbot makes voice ticketing, voice check-in and voice searching come true (Sankaranarayanan & Lalchandani, 2017). From Table 2, it can be seen that the overall development level of digitalization and intelligentization of developing countries are lower than it of developed countries. More investment on high-tech and more resources available make it easier for developed countries to get improvement. Moreover, developed countries also paid attention to air transport development earlier than in developing countries. However, China is an exceptional country. The development of high-tech used in ATS in China is even faster than some of developed countries.

From the above comparative analysis results, it can be concluded that countries with a high level of digitalization have a better performance in their aviation industry. Therefore, it is meaningful to study the impact of digitalization and intelligentization on air transport in these different countries.

Secondly, the correlation results are showed in theTable 2. Internet users, high-tech export, digital ranking and number of airlines are selected to analyze their effects on ATS in different countries. In these indicators, Internet users, high-tech export and digital ranking represent the development of digitalization and intelligentization in these countries, and number of airlines represents the technology development and current capacity of ATS in these countries. Besides, correlation analysis bases on four factors: passenger carried, registered carrier departure, air transport accident and freight. Due to the data limitation

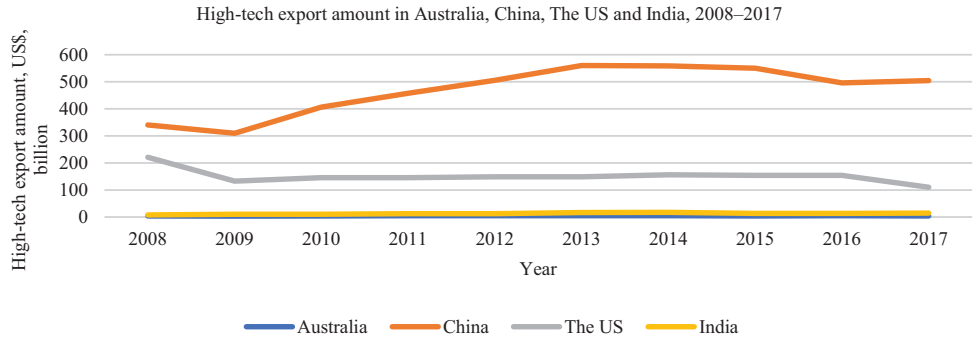

Figure 2. High-tech export amount in Australia, China, The US and India from 2008 to 2017, US$ in billion

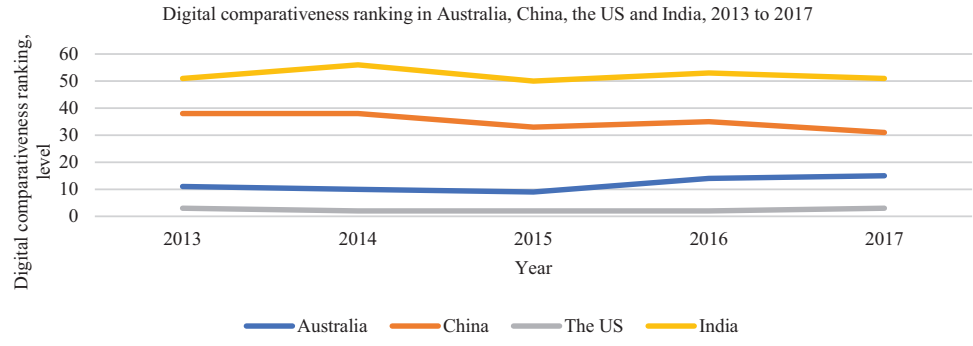

Figure 3. Digital comparativeness ranking in Australia, China, the US and India from 2013 to 2017, level

Table 2. The biometric technology, AI impact and startups in aviation in Australia, China, the US and India about in 2018

Indicator	Country	Status
Biometric Technology (%)	Australia	1.10% of airports
	China	12.2% of airports
	The US	0.15% of airports
	India	0.00% of airports
AI Impact Rank (level)	Australia	10 (Score: 70.4)
	China	12 (Score: 67.1)
	The US	9 (Score: 72.0)
	India	18 (Score: 47.2)
Startup year for the first commercial airline (year)	Australia	1921
	China	1981
	The US	1924
	India	1931

Table 3. Correlation analysis result for four sample countries from 2008 to 2017

Factor	Passenger carried				Registered carrier departures			
	AU	CHN	USA	IND	AU	CHN	USA	IND
Internet users	0.95	0.96	0.79	0.98	0.90	0.97	–0.24	0.97
High-tech export	0.74	0.71	–0.40	0.51	0.78	0.74	–0.46	0.47
Digital ranking	0.87	–0.87	0.02	–0.26	0.45	–0.87	0.74	–0.23
Number of airlines	0.84	0.97	0.95	–0.66	0.75	0.90	0.20	–0.64
Factor	Air transport accident				Freight			
	AU	CHN	USA	IND	AU	CHN	USA	IND
Internet users	0.02	–0.56	0.17	–0.23	–0.71	0.91	0.22	0.88
High-tech export	–0.26	–0.58	0.39	–0.11	–0.25	0.67	–0.04	0.65
Digital ranking	0.69	0.44	0.63	0.31	0.12	–0.89	0.35	–0.18
Number of airlines	0.16	–0.55	–0.13	0.40	–0.71	0.88	0.32	–0.75

and the topic limitation, these factors are the most suitable to be selected and analyzed.

From the correlation results, it can be concluded that the impact levels of digitalization and intelligentization on ATS in these four countries are different. The score of impact factor which over 0.9 shows very high correlation between variables and the impact score which over 0.8 shows high correlated relationship between variables. Based on this theory, it can be concluded that, for Australia, Internet user has a very high positive correlation with air transport passengers carried and registered carrier departures. This means that digitalization and intelligentization have impact on the development of ATS in Australia. For China, digitalization and intelligentization have the hugest impact on the development of ATS. Number of Internet users and number of airlines have huge impacts on air transport passenger carried, registered carrier departures and freight delivered. The most effective factor for Indian ATS is the number of Internet users. It affects air transport passenger carried, registered carrier departures and freight delivered. For the US, the impact of digitalization and intelligentization on ATS is not as much as the above countries. There is only a very high positive correlation relationship between passengers carried and number of airlines. However, for all these four countries, digitalization and intelligentization have little influence on air traffic accidents.

Thirdly, the regression analysis will be presented. Based on the results of correlation analysis, some meaningful factors will be selected for the following analysis. For each sample country, all of the four impact factors are analyzed in the regression analysis, however, only the factors which have p-value below 0.05 will be selected. It should be mentioned that since digitalization and intelligentization have little impact on air traffic accident in all of the sample countries, the relationship between these indicators would no longer be analyzed in the regression analysis.

Table 4 and Figures 4–7 show the regression results when using passenger carried as the dependent variable.

Table 4. Regression analysis of passenger carried in Australia, China, The US, India from 2008 to 2017

(Dependent variable: Passengers carried)	Coefficients	Standard Error	p-value
Australia			
Intercept	–3086078	8296193	0.7
Internet users	3.638	0.4	3.6822×10^{-5}
China			
Intercept	–133125035	46155321	0
Number of airlines	12857548	1196078	4.9353×10^{-6}
The US			
Intercept	–480772412	137121739	0
Number of airlines	9206009	1020967	1.8277×10^{-5}
India			
Intercept	43895175	3389318	1.1965×10^{-6}
Internet users	0.226	0	6.6417×10^{-7}

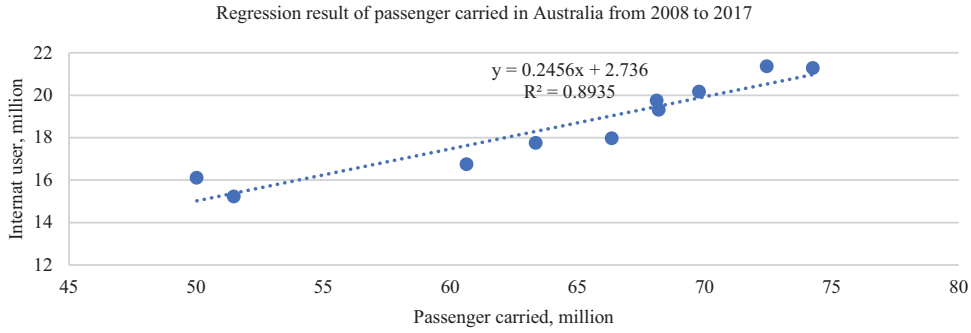

Figure 4. Regression result of passenger carried in Australia from 2008 to 2017

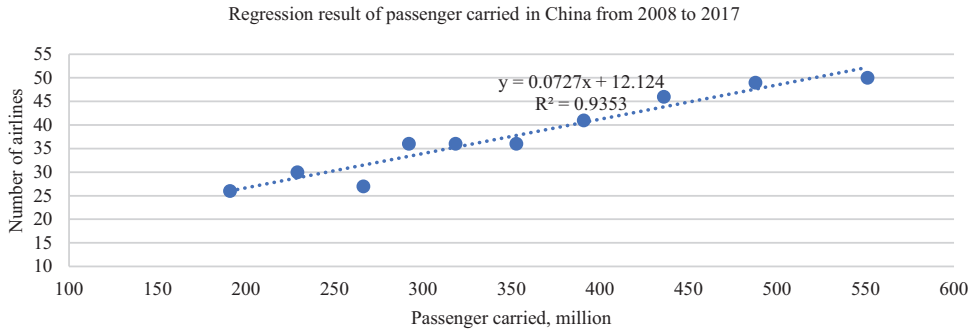

Figure 5. Regression result of passenger carried in China from 2008 to 2017

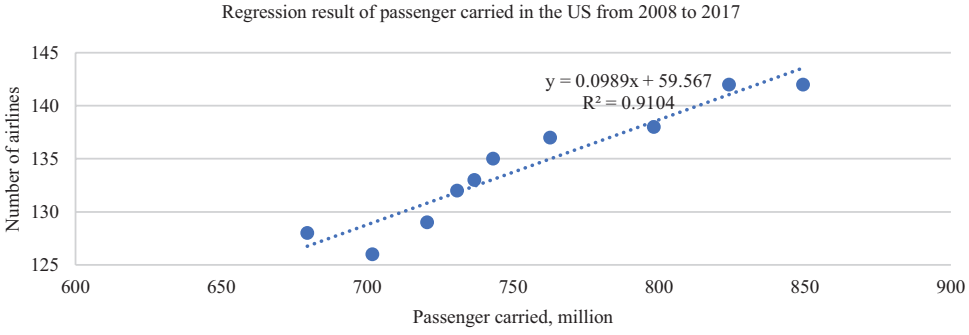

Figure 6. Regression result of passenger carried in the US from 2008 to 2017

For Australia, in the passengers carried regression analysis, Internet users is selected in the model as the independent variable which has strong relationship with the dependent variable. For China, in the passengers carried regression analysis, number of airlines is selected in the model as the independent variable which has strong relationship with the dependent variable. There is only one model could be effective regression analyzed for the US's ATS. Number of airlines is used in the US's passengers carried regression model as the independent variable. For India, in the passengers carried regression analysis, Internet user has the strongest relationship with the dependent variable.

Table 5 and Figures 8–10 show the regression results when choosing registered carrier departures as the dependent variable.

For Australia, in the registered carrier departures model, the independent variable which has the strongest relationship with the dependent variable also is Internet users. For China, the independent variable for registered carrier departures regression model is Internet users. For India, in the registered carrier departures model, Internet user has the strongest relationship with the dependent variable

Table 6 and Figure 11 show the regression results when choosing freight as the dependent variable.

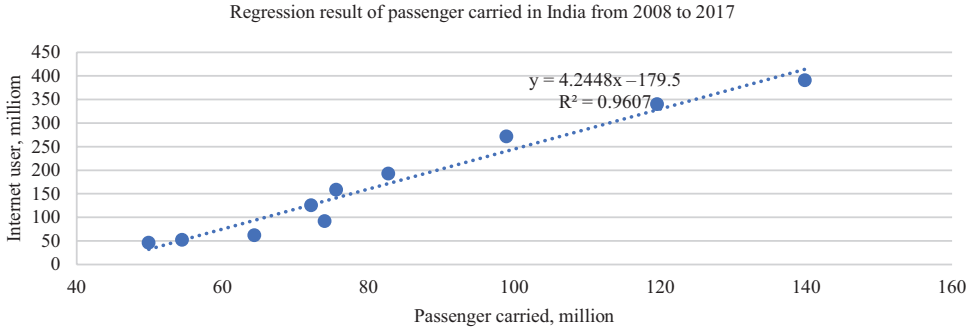

Figure 7. Regression result of passenger carried in India from 2008 to 2017

Table 5. Regression analysis of registered carrier departures in four sample countries from 2008 to 2017

(Dependent variable: Registered carrier departures)	Coefficients	Standard Error	p-value
Australia			
Intercept	–246033	148342	0.1
Internet users	0.0045	0	0
China			
Intercept	53947	281267	0.8
Internet users	0.005	0	4.6917×10^{-6}
India			
Intercept	541164	20569	4.681×10^{-9}
Internet users	0.001	9.8243E-05	3.3406×10^{-6}

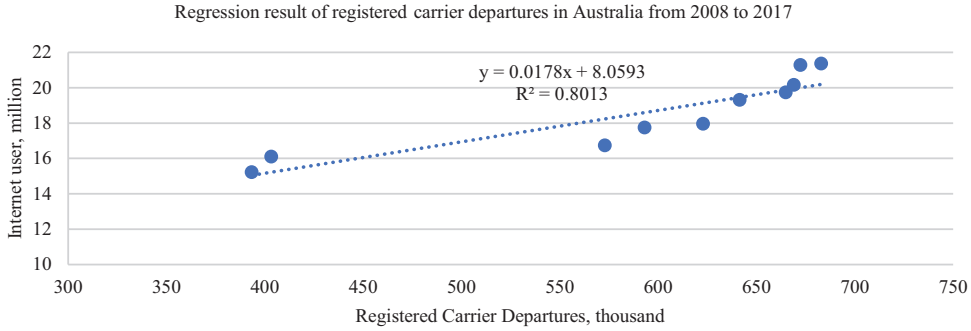

Figure 8. Regression result of registered carrier departures in Australia from 2008 to 2017

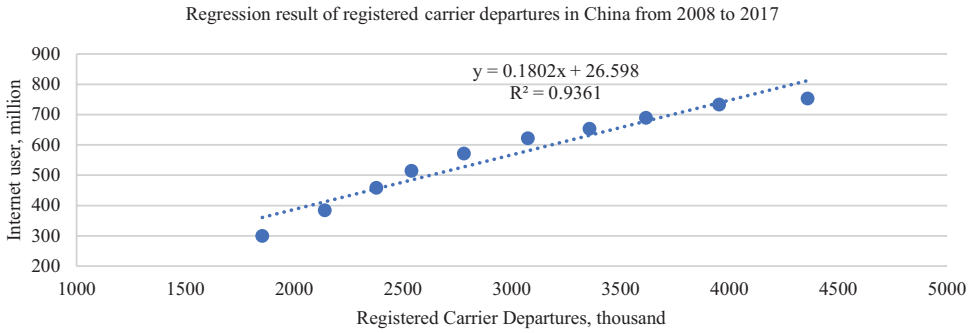

Figure 9. Regression result of registered carrier departures in China from 2008 to 2017

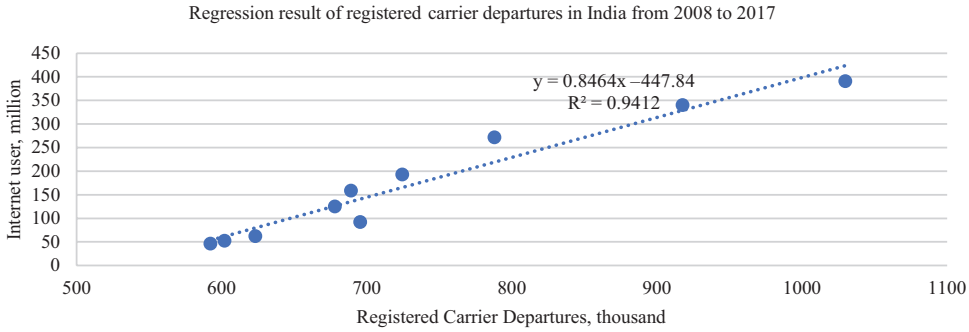

Figure 10. Regression result of registered carrier departures in India from 2008 to 2017

Table 6. Regression analysis of freight in four sample countries from 2008 to 2017

Dependent variable: Freight	Coefficients	Standard Error	p-value
India			
Intercept	1293	97	9.62363×10^{-7}
Internet users	2.4042×10^{-6}	4.6361×10^{-7}	0

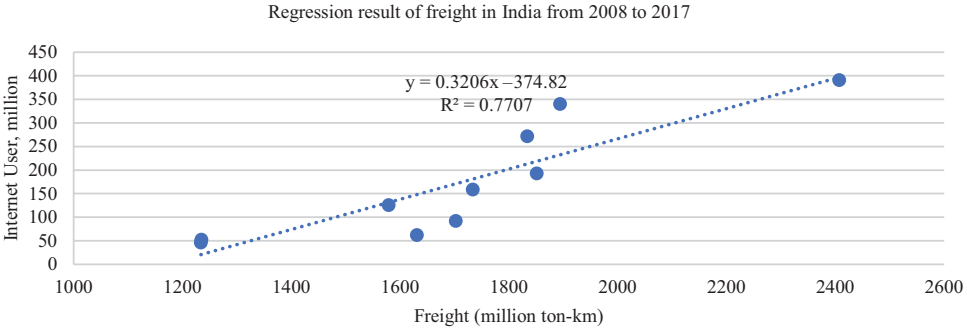

Figure 11. Regression result of freight in India from 2008 to 2017

3.2. Forecasting models

Based on the results from last section, some forecasting models could be obtained. Table 7 shows the forecasting models for each countries' ATS.

It can be seen that, for Australia, both of the number of passenger carried by air transport and the registered carrier departure in air traffic will increase with the number of Internet users. From the previous data, it could be expected that the increasing trend will continue, the number of passenger carried and the number of registered carrier departure will increase in the next few years. For China, since the dependent variables are positive related to the independent variables, the increase of number of airlines will lead to the rising of passenger carried. Also, the registered carrier departure will increase with the number of Internet users. Based on the current data, it could be

Table 7. Forecasting models for each countries' ATS

Country	Forecasting model			
	Passenger carried	Registered carrier departures	Air transport accident	Freight
Australia	Passengers carried = –3086078 + 3.638 (Internet users)	Registered carrier departure = –246033+ 0.045 (Internet users)	Not significant	Not significant
China	Passengers carried = –133125035 + 12857548 (Number of airlines)	Registered carrier departure = 53947+ 0.005 (Internet users)	Not significant	Not significant
The US	Passengers carried = –480772412+ 9206009 (Number of airlines)	Not significant	Not significant	Not significant
India	Passengers carried = 43895175 + 0.226 (Internet users)	Registered carrier departure = 541164+ 0.001 (Internet users)	Not significant	Freight = 1293+ 2.4042E-06 (Internet users)

inferred that both the passenger carried and registered carrier departure will present positive trends in the future. The number of passenger carried by air transportation in the US increases with the number of airlines. With the increase trend of the number of airlines in the US, it could be inferred that the trend of passenger carried will also be positive in the next few years. Besides, it can be seen that all these three dependent variables are positive related to the number of Internet users in India. However, based on the available data, the number of Internet users is not stable. Therefore, it is difficult to infer the future trends of passenger carried, registered carrier departure, and freight in India.

It can be seen that the forecasting result of air traffic accident does not significant in all these four countries. Besides, only in India, it could be assumed that digitalization and intelligentization have a significant relationship with the freight delivered by air transportation. All in all, it still could be able to predict the future trend of passenger carried and registered carrier departure in these countries if the data of the correlated independent variables are available.

4. Implication

From the above analyses, the elements in digitalization and intelligentization which impact ATS could be found to help develop investment plans and improvement strategies. The samples both contain developed and developing countries, thus, it is meaningful to compare the development levels of digitalization and intelligentization and their ATS. Correlation analysis illustrates the effective correlation between ATS and digitalization and intelligentization, this also identifies the most impact factors which need to be focused on to improve ATS. Regression analysis and forecasting analysis could help to predict how to enhance ATS's performance under the current development trend of digitalization and intelligentization. However, when applying these results, there may be some dilemmas. For example, it may be difficult to obtain the accurate predicted data of independent variables, this will lead to the inaccurate results of forecasting analysis. From the results above, it can be concluded that the number of Internet users and number of airlines are effective factors for both developed and developing countries to predict the future trends of ATS.

Conclusions

From the results and analyses above, it can be concluded that digitalization and intelligentization have affected the development of ATS. Moreover, in most countries, digitalization and intelligentization have positive impacts on their ATS. Besides, based on the correlation results, the most significant impact factor could be obtained. In Australia, the impact score of Internet Users for its air travel passenger carried and registered carrier departures are both over 0.9. In the US, the impact score of the Number of Airlines for its air travel passenger carried is 0.95. In India, the impact score of Internet Users for its air travel passenger carried and registered carrier departures are 0.97 and 0.98 respectively. In China, the impact score of Internet Users for its air travel passenger carried, fright and registered carrier departures are all over 0.9. Thus, it could be inferred that the situation of digitalization and intelligentization's impact on ATS in these four countries is different. Not only the impact factors, but the impact level is also different in these countries. Digitalization and intelligentization have the hugest impact on China's ATS, however, the impact level of digitalization and intelligentization on the US's ATS is lowest. What interesting is that unlike publics' thinking, digitalization and intelligentization actually have little impact on the occurrence of the air transport accident.

From the results, the future investment direction in air transportation in these four countries can be determined. In different countries, the digitalization level and the most impact factors for ATS are different. Therefore, according to the different performance of ATS in these countries, investors can set up different investment plans to obtain higher returns. Besides, identifying the impact of digitalization and intelligentization on ATS in these countries can also provide a basis for econometric modeling. Then the development trends and economic activities can be identi-

fied by these econometric models. Also, the results show the most impact digital and intelligent indicators for ATS in each sample countries. Thus, these indicators can be referenced in the future development strategies for ATS and to help it get better performance.

Recommendation and future works

Firstly, it could be concluded that digitalization and intelligentization have different impacts on ATS in different regions. According to the different impact levels, various investment activities for ATS and digitalization and intelligentization could be carried out. Moreover, publics have a huge impact on the development of ATS and digitalization and intelligentization. For developing countries like China and developed countries like the US and Australia, since there are already many digital and intelligent technologies applied, it is more important to introduce these applications to passengers. More promotion and advertising could be placed to help people understand the impacts of digitalization and intelligentization on ATS. Passengers are willing to use mobile applications, high-tech machines, and other digital technologies to improve their travel experience. If more promotion and advertisement can be placed, passengers could know the current digital applications they can use. It also provides an opportunity for airlines to attract more customers by promoting their digital applications. For developing countries like India, although they start paying attention to the applying of digital and intelligent technologies, the application rate of these high-techs is still not as high as the above countries. Therefore, in these regions, more high-tech facilities like e-gate and self-check-in should be put into use to simplify the process and make people's lives become more convenient. Compared with human work, e-gate, self-check-in, and other digital technologies can make the right decision in a shorter time. Also, since these high technologies can identify passengers and verify the different situations sensitively, the security and efficiency in ATS can also be improved.

Due to the time and resource limitations in the current stage of research, the results obtained in this paper may have some limitations. In the future works, more sample countries and impact factors could be selected to better the results.

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