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Air mobility of people and airport growth potential in regions of Russia

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Abstract. The article is about Russian regional airports, air mobility of people in regions of Russia, geographical distribution and results of econometric forecasting of these figures based on demographic and economic factors. Also some historical reviews, a description of the current situation and international comparisons are provided. The research revealed that people's income and investment (both current and accumulated) are the main factors affecting air transportation growth in the studied airports. In the long-term perspective air traffic of Russian airports can triple by 2030, while Russian air mobility figures can exceed the present ones in Western Europe.

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Contents:

1. Introduction

Commercial aviation within recent decades has transformed air transport from a combination of adventure and premium service into a commodity. Regular passenger air services began in Russia in 1923 but it took half a century to develop them into a frequently used way of transportation. While in the Western world air travelling was widespread already in the 1960s, soon after passenger jets introduction, in Russia the same conditions were reached by the 1980s. It happened only thanks to the extensive state support of the industry that included the construction and maintenance of regional and local airports, sponsored jet fuel prices, encouraging aircraft manufacture, a centralised system of transportation planning with diverse air routes and multiple connections. The operations of Soviet Aeroflot and its regional divisions are an interesting area of study as the air transportation development in every region was a fusion of economically-based and politically-motivated factors integrated in a geographical background.

The turbulence of the 1990s resulted in a dramatic decline of air services in Russia, while the years of subsequent economic growth have resulted in the booming development of air transportation in the country. The annual increase in the number of passengers of Russian airports greatly exceeds GDP growth rate in Russia as well as in other neighbouring countries, and Kazakhstan in particular. However, the aviation mobility of people varies greatly in different regions of the country as well as in different nations of Eastern Europe. Aviation mobility of people thus may be used as one of the key indicators of the real socio-economic level of development of a territory in addition to other non-monetary and indirect indicators (such as the number of cars per capita or cell network coverage) found in geographic studies (Treyvish, 2009).

Forecasting air mobility and the related airport growth is of particular importance as there is a great public and commercial interest in the issue. An airport terminal appears to be the first object that any traveller looks at upon arrival, and thus for regional residents and authorities it is it is a matter not only of the infrastructure, but also of the status of the city and the region.. In some cases it can provide a strong basis for the development of local services and can be turned into a centre of local economic growth (Stevens et al., 2010). That is why any public announcement about turning a local airport into an 'international hub' has a strong media effect although many official forecasts of growth are too optimistic. The overestimation of growth is the feature of not only Russian, but of some Western European airports, too (Samagaio, Wolters, 2010). At the same time, business is very interested in investing in Russian airports as the booming industry looks very attractive. There are already four large private holdings managing multiple major airports in Russia, and fierce competition for overtaking the remaining government-owned objects. As several completed projects have failed to meet the planned figures, a correct calculation of an airport potential of growth appears to be the key factor in the financial performance of such investments. Thus, forecasting the air mobility of population has a practical meaning in addition to great scientific importance.

Russian aviation community clearly understand the urgency of the need for applying mathematical and statistical methods for forecasting regional commercial aviation indicators (Borisov, 2012). Nowadays such methods are used by Russian air companies primarily for routine tactical issues, not for strategic planning (Komaristy, 2006). Traditional approaches to forecasting national air transportation figures have a strong preference for macroeconomic indicators like GDP growth (Komaristy, 2006), although it has been proved that the aggregation of detailed forecasts for individual airports provides better results, even taking into account the lower quality of models for smaller airports (Strand, 1999; Carson et al., 2011).Macroeconomic indicators naturally have strong impact on international long-haul traffic (Dennis, 2002). In academic circles there are numerous works about econometric modelling passenger traffic, but most of them can be applied to ground and rail transportation only. At the same time, aviation experts prefer to deal mainly with network traffic redistribution models and air hubs development problems, but not with forecasting air traffic itself (Evans, Schäfer, 2011; Suau-Sanchez, Burghouwt, 2011; Sismanidou et al., 2013). Accordingly, in the geographical community air transportation has long been the shadowed area of study with scientists mainly focusing on network analysis of ground and urban transportation or estimation of the hinterlands of large cities (Isard, 1960; Lieshut, 2012).

Despite the general understanding of the necessity to use mathematical and statistical methods for modelling and forecasting air traffic, there is a long-lasting discussion about whether econometric models could be correctly applied for these purposes. The relation between the air mobility of people and the economic development of the region owhere the airport is located is evident. Some interesting works have been even published on the use of air routes network for determining the network of global cities (Derudder, Witlox, 2008). Traditional econometric regression models and trends are not the only types of mathematical models used for forecasting air traffic. Some researchers find it better to use the more complex Markov-chain-based grey forecasting (Hsu, Liu, 2003), neural networks (Alekseev, Seixas, 2009) and other AI-based models but they provide not very understandable and unclear results. A more serious criticism of econometric models concerns the significance of non-market factors that cannot be taken into account: changes of institutional environment, deregulation of the industry, emergence of low-cost air carriers, airports capacity limits and the development of ground transportation. Any of these changes may completely ruin the previous econometric researches as their results are correct only if no new strong factor will emerge (Graham, 1999; Profillidis, 2012). Lack of historical data resulting from dramatic institutional changes can be compensated for by the use of data of peer airports (Cline et al., 1998), although individual airports display more differences and specific features than similarities (Strand, 1999).

The deregulation of the market and the emergence of low-cost air carriers can abnormally increase the overall air mobility but with varying effects on different airports. In the United States, market deregulation resulted in decline of services in smaller airports and increase of traffic in major hubs (Goetz, Vowels, 2009), while in Greece deregulation within the EU had no major effect on national air industry (Papatheodorou, Arvanitis, 2009). In Russia, the disintegration of the former Soviet Aeroflot resulted in a massive decline of non-capital airports already in the early 1990s and the subsequent centralisation of air traffic in Moscow. Two attempts to launch Russian low-cost services in the late 2000s failed. The improvement of ground transportation, the other breaking factor, has had in other countries strong negative effect on short-haul airport services and on the development of secondary and regional airports (Matthiessen, 1993), but in Russia even high-speed rail development has not yet severely impaired air industry (Kramarenko, 2013) due to very high demand for transportation and strong market growth. Thus, traditional objections against the implementation of econometric models to air mobility and air traffic growth do not appear so serious in Russian conditions. That is why econometric modelling can provide good results for forecasting of air mobility of people and passenger traffic in Russian airports. It is very likely, however, that with the upcoming maturity of the market and the slowdown of its growth some factors will have a greater effect on the industry. For minor regional and remote airports, the recently begun policy of government-subsidised air fares has already had a strong impact on traffic volumes, so that theexpected figures should be much lower than the reported ones.

This research has been performed by the author in order to review air transportation development in Russia, statistically verify the theory that air mobility of people and passenger air traffic depend on economic indicators of the region, and build the forecast of air mobility of people and passenger air traffic for major Russian airports. It has been done using data analysis and forecasting program tools of Russian IT and business intelligence ‘Prognoz’ Company.

2. Research methodology

The research consists of several parts. The first phase is just a calculation of aviation mobility figures in the main Russian and Kazakhstani airports and their hinterlands. The calculation has been performed by a simple division of the annual number of passengers of an airport by the sum of permanent residents of the area served by the airport. These areas borders have been estimated by the author according to the knowledge of Russian regional centre-periphery relations and analysis of statistics of some minor regional airports which have no independent hinterlands of their own. Unlike in Western Europe (Lieshout, 2012) there is no great competition between airports in Russia due to their relatively low density and inherited from planned economy industrial infrastructure. The subsequent phase of the research uses demographic data in the regional breakdown only; accordingly, if a region has several airports, their statistics have been merged.

The result of the first phase is a matrix of time series data of aviation mobility for around 40 Russian airports and groups of airports. After this matrix is generated, another matrix filled with calculated correlation coefficients between all the airports has been built. This correlation matrix has been used to find clusters of similar air mobility dynamics in different groups of Russian regions. A cluster itself consists of closely related time series of airports (the core) with a surrounding of more loosely related time series (pretenders). Every determined cluster has been then properly described.

The second phase of the research is the forecasting of the number of permanent residents of Russian regions according to population age structure (Fedstat, 2012) with a well-established method of generations' age transition (simply speaking, if a person is now aged 20, it is likely that he or she will turn 25 within five years in the region with some probability calculated according to historical data, see Fig. 1). Coefficients of age transition are set as constant ones while birth rate is traditionally forecasted not with factor models but using the linear trend of birth rate in active reproductive ages (Kirillov, 2013). The result of the second phase is a matrix of forecasted time series of the population of Russian regions by 2030. The same operations have been performed for the regions of Kazakhstan (Kazstat, 2012) located in the hinterlands of Almaty and Astana airports. These two airports have been selected because of their dominant positions in the republic, and the availability of sufficient data, both demographic and traffic, for the historical period.

$$P_{n,t} = P_{n-1,t-1} \times \frac{\sum_{j=1}^{t-1} \frac{P_{n,j}}{P_{n-1,j}}}{t-1}$$

Fig 1. Calculation of population aged n in a period t, according to age transition method of demographic forecasting

The third phase of the research deals with forecasting the number of passengers served by seven Russian airports selected to represent different locations and types. The forecasting uses econometric modelling (namely, non-linear regression) based on official statistics of Rosstat processed by Prognoz. It requires forecasts of influencing factors; the range of forecast is three years. This phase is set to mathematically reveal the major factors affecting the airports' activity in different Russian regions, toestimate the share of common and specific factors for every studied airport, and to compare the results with the clusters from the first phase of the research. Seven airports have been selected, located in Yekaterinburg, Barnaul, Magadan, Volgograd, Vladivostok, Anapa and Chita. They represent not only different geographical areas of Russia but also different types of regions and cities: an interregional center (Yekaterinburg), the densely populated industrial-rural areas of Volga and Siberia (Barnaul and Volgograd), a sea resort (Anapa), a remote East-Siberian city (Chita), a half-isolated city in the North (Magadan) and a frontier transportation and transit trade centre (Vladivostok).

In the fourth phase long-term trends of aviation mobility of population of regions of Russia and Kazakhstan are built using the logistic growth model (Fig. 2). This model of growth has been chosen because of the fact that air mobility has some limits of growth and after rapid progress starting from the low base the growth rates will constantly decrease due to the increasing preasure of the socio-economic environment. For example, recreational trips cannot be too frequent due to the limited number of holiday periods, while air business trips cannot consume too much working time and already experience some pressure from online services.

$$P(t) = \frac{K \times P_0 \times e^{RT}}{K + P_0 \times \left(e^{RT} - 1\right)}$$

Fig. 2. Logistic growth trend model formula, where *P(t)* is air mobility and *t* is a number of the period

After air mobility logistic trend values have been calculated, then the potential of growth of the number of passengers served by airports can be easily estimated by multiplying the projected aviation mobility by the projected number of local residents. The final figure represents the projected number of passengers served by different airports. As the statistics of airports located in the same region has been merged, the potential of growth calculated in this way should be taken as equal for all airports of a given hinterland.

The fifth and final phase of the research deals mainly with comparisons of aviation mobility of the population in regions of Russiato Kazakhstan, Baltic countries, Belarus, the Ukraine, Moldova, Georgia, Armenia, Hungary and the hinterland of Warsaw. These peers were chosen according to three criteria: availability of airport statistics, common history of centralised aviation development and clear hinterland borders. Available demographic data allows to build time series of air mobility for some of these airports so as to compare dynamics with the Russian and Kazakhstani peers and to estimate the delay in socio-economic development in the countries with this indicator. These comparisons provide the basis for the final conclusions about the subject of the research.

3. Analysis and results

Statistical data of the number of passengers served in Russian airports is available only since 1995 (Association…, 2012), for Astana airport since 2000, while data for Almaty airport as well as for some minor Russian airports is fragmented and must be collected from different sources, but in general begins from 2005. Demographic data for Russian regions is available since 1990, while for regions of Kazakhstan demographic data begins from 2000 only.

All hinterlands of Russian airports can be classified by current air mobility (annual number of flights per capita) into six groups (see Table 1): fading (less than 0.1); extremely low (less than 0.2); low (less than 0.3); moderate (less than 0.65); high (less than 2); very high (2 and more). The general trend is that larger airports normally have higher air mobility but there are many exceptions. Airports in the first group have always had higher than average air mobility, but they do not have large passenger traffic. All of them are airports in the North with indicator values of 1.6–1.7. However, some minor and remote airports not included in the survey due to lack of historical demographic data have even larger values, with Gazprom's Yamal cities of Noviy Urengoy and Salekhard being visible leaders with 5.1 and 6.8 respectively. Higher air mobility in sparsely populated areas is a feature of many countries and has been noticed even on the well-developed US market (Russon, Vakil, 1995). Unlike the northern airports, the airport of Samara has low air mobility (0.32) although it serves around 2 mln people annually. Some other large airports, like Chelyabinsk, Mineralnye Vody and Kazan, are rapidly improving air mobility of their hinterlands despite the fact that they have lagged behind for many years.

The historical overview of air mobility demonstrates the economic dynamics of individual Russian regions as well as the overall trends of regional inequality in the country. As historical data is available only since 1995, it is not possible to analyse the period of the most violent decline of air mobility in the early 1990s resulting from the collapse of the centralised state-supported old Aeroflot. However, despite the economic indicators which showed signs of revival in the middle of that troubled decade, air mobility decline progressed and reached its lowest level in 1999–2000. Statistical analysis of variance of air mobility growth rates for that period revealed relatively low diversity of airport figures' dynamics as the fall was universal. Only several Russian airports had positive dynamics in the late 1990s, mostly due to the implementation of notable oil and gas projects (Astrakhan, Sakhalin), while regions with mining, metallurgical and manufacturing economies were outsiders.

The pPeriod of rapid economic growth in Russia in the 2000s could be divided into two phases. The first phase lasted until 2004 and lifted up metallurgical and port regions and their airports (Krasnoyarsk, Kemerovo, Arkhangelsk, Kaliningrad, Abakan and others). The second phase of booming oil prices naturally increased air mobility in oil- and gas-dependent regions (Kazan, Perm, Volgograd, Ufa, Nizhny Novgorod, Komi airports, Astrakhan and others). Both groups, however, suffered heavily during the late 2000s economic crisis as prices for commodities dropped and economic activity shrank. The variance of air mobility growth rates during the crisis decreased almost to zero while in previous years due to uneven resource-based economic growth it was constantly increasing. In recent post-crisis years, the variance of growth rates of air mobility has been relatively low thanks to the increased centralisation of Russian economy and the postponed development of some minor airports.

In geographical breakdown of the indicator some trends can be traced, too (see Fig. 3). The first and most important one is the absolute leadership of Moscow and St Petersburg airports among oth-

Table 1. Air mobility in hinterlands of airports of Russian regions in 1995–2012, annual number of trips per capita (higher values have lighter shades of grey)

	cluster	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Magadan		1.19	1.03	0.90	0.79	0.73	0.63	0.65	0.68	0.68	0.82	0.98	1.02	1.13	1.19	1.22	1.51	1.77	2.13
Airports of Moscow	1a	0.62	0.52	0.56	0.54	0.51	0.51	0.58	0.62	0.72	0.83	0.91	1.03	1.22	1.35	1.28	1.59	1.69	1.91
Petropavlovsk-Kamchatsky		1.27	1.01	0.80	0.74	0.84	0.76	0.88	0.96	1.00	1.10	1.16	1.21	1.27	1.29	1.35	1.50	1.72	1.89
Yuzhno-Sakhalinsk	1b	0.59	0.52	0.55	0.49	0.53	0.51	0.57	0.65	0.78	0.88	1.01	1.11	1.20	1.28	1.22	1.46	1.56	1.70
Anadyr			0.97	0.75	0.71	0.77	0.80	1.68	1.57	1.81	1.89	1.91	1.76	1.76	1.66	1.50	1.68	1.64	
St Petersburg	1a	0.36	0.34	0.32	0.31	0.30	0.32	0.36	0.40	0.48	0.56	0.62	0.66	0.81	0.94	0.89	1.12	1.21	1.41
Kaliningrad		0.37	0.29	0.27	0.25	0.28	0.25	0.27	0.29	0.50	0.67	0.70	0.78	1.17	2.00	1.45	1.09	1.31	1.26
Khabarovsk	1b	0.66	0.55	0.50	0.41	0.41	0.37	0.41	0.45	0.49	0.53	0.53	0.58	0.60	0.64	0.74	0.92	1.05	1.25
Novosibirsk	1a	0..54	0..49	0..54	0..44	0..39	0..32	0..36	0..42	0..47	0..53	0..55	0..58	0..71	0..80	0..68	0..85	1..04	1..23
Tyumen	2a	0..71	0..49	0..50	0.43	0.39	0.40	0.41	0.44	0.44	0.46	0.51	0.56	0.65	0.68	0.59	0.72	0.80	0.92
Airports of Krasnodar region	1a		0.37	0.35	0.33	0.39	0.35	0.37	0.35	0.40	0.46	0.48	0.52	0.60	0.63	0.59	0.78	0.87	0.89
Krasnoyarsk		0.51	0.35	0.34	0.35	0.36	0.33	0.43	0.49	0.53	0.55	0.52	0.54	0.59	0.48	0.50	0.59	0.77	0.87
Vladivostok	1a	0.35	0.31	0.30	0.26	0.27	0.24	0.29	0.33	0.36	0.42	0.42	0.44	0.48	0.52	0.50	0.64	0.75	0.85
Yekaterinburg	1a	0.23	0.18	0.17	0.15	0.15	0.15	0.17	0.20	0.23	0.27	0.27	0.31	0.42	0.47	0.39	0.51	0.64	0.73
Murmansk		0.57	0.42	0.36	0.31	0.30	0.24	0.25	0.27	0.32		0.32	0.32	0.42	0.47	0.41	0.56	0.69	0.69
Arkhangelsk	1b	0.27	0.17	0.14	0.16	0.16	0.14		0.16	0.19	0.31	0.26	0.27	0.31	0.38	0.38	0.53	0.64	0.60
Irkutsk	2a	0.39	0.32	0.25	0.21	0.22	0.20	0.22	0.25	0.26	0.29	0.27	0.32	0.41	0.42	0.34	0.43	0.52	0.58
Ufa	2a	0.34	0.23	0.20	0.16	0.14	0.15	0.18	0.17	0.18	0.20	0.21	0.24	0.28	0.33	0.30	0.37	0.42	0.47
Airports of Komi	3a	0.53	0.32	0.29	0.22	0.17	0.14	0.13	0.11	0.11	0.14	0.19	0.23	0.25	0.29	0.23	0.34	0.42	0.45
Omsk	2a	0.31	0.22	0.20	0.16	0.15	0.15	0.17	0.17	0.20	0.22	0.22	0.21	0.28	0.27	0.25	0.30	0.37	0.44
Rostov-on-Don	1a	0.17	0.14	0.14	0.11	0.11	0.11	0.12	0.12	0.13	0.14	0.16	0.17	0.24	0.30	0.27	0.34	0.40	0.44
Tomsk	2b	0.31	0.24	0.24	0.19	0.15	0.15	0.20	0.23	0.24	0.25	0.24	0.29	0.28	0.28	0.25	0.32	0.37	0.41
Perm	1a	0.13	0.10	0.09	0.07	0.06	0.06	0.07	0.06	0.09	0.10	0.11	0.13	0.19	0.25	0.21	0.28	0.33	0.38
Astrakhan		0.09	0.18	0.13	0.09	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.14	0.18	0.21	0.22	0.33	0.34	0.33
Samara	1b	0.19	0.15	0.17	0.14	0.13	0.12	0.13	0.13	0.14	0.15	0.16	0.19	0.20	0.25	0.22	0.27	0.30	0.32
Blagovechshensk		0.12	0.09	0.12	0.10	0.10	0.07	0.09	0.11	0.13	0.14	0.14	0.15	0.18	0.17	0.14	0.18	0.23	0.29
Chelyabinsk	2a	0.20	0.16	0.11	0.08	0.09	0.09	0.07	0.07	0.09	0.10	0.10	0.12	0.19	0.19	0.17	0.19	0.24	0.29
Ulan-Ude	3b	0.26	0.18	0.13	0.10	0.10	0.09					0.16	0.12	0.14	0.15	0.13	0.17	0.19	0.28
Airports of Tatarstan	1a	0.07	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.08	0.10	0.13	0.16	0.15	0.21	0.27	0.26
Orenburg	2b	0.16	0.13	0.12	0.09	0.08	0.07	0.07	0.06	0.07	0.12	0.09	0.12	0.17	0.17	0.12	0.16	0.21	0.23
Chita		0.19	0.15	0.10	0.06	0.05	0.04	0.05	0.06	0.07	0.09	0.10	0.11	0.13	0.14	0.11	0.15	0.18	0.22
Mineralnye Vody	3a	0.19	0.14	0.12	0.10	0.10	0.09	0.08	0.09	0.10	0.10	0.10	0.11	0.13	0.14	0.12	0.15	0.16	0.21
Volgograd	2b	0.16	0.14	0.11	0.08	0.08	0.08	0.08	0.07	0.07	0.08	0.09	0.11	0.13	0.16	0.13	0.17	0.19	0.20
Kemerovo and Novokuznetsk		0.13	0.08	0.06	0.05	0.06	0.05	0.06	0.07	0.08	0.10	0.13	0.14	0.13	0.14	0.12	0.16	0.17	0.19
Nizhniy Novgorod		0.06	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.03	0.04	0.04	0.05	0.07	0.08	0.07	0.09	0.11	0.18
Abakan		0.16	0.10	0.07	0.06	0.06	0.05	0.05	0.06	0.07	0.09	0.09	0.09	0.11	0.11	0.10	0.11	0.12	0.16
Barnaul	1b	0.08	0.06	0.05	0.04	0.04	0.05	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.11	0.10	0.12	0.14	0.14
Voronezh	2b	0.08	0.07	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.03	0.04	0.05	0.07	0.09	0.06	0.09	0.12	0.13
Saratov	3a	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.04	0.05	0.05

Source: Author's calculation

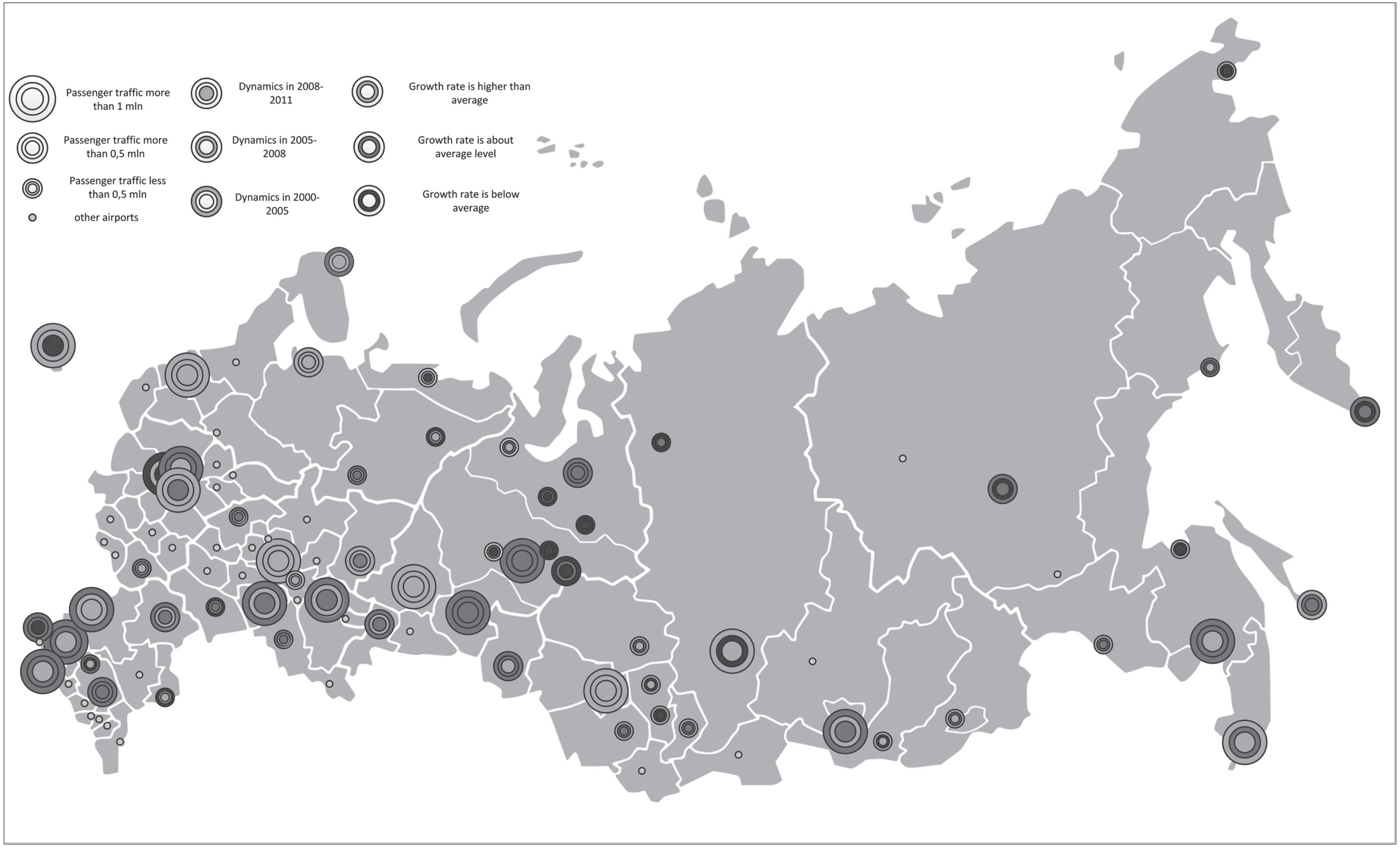

Fig 3. Major Russian airports' location, size and dynamics of their passenger traffic in 2000–2011

Source: Author's own work

er non-northern hinterlands (Bukalova, 2012). This is likely the result of not only higher economic activity but also of the post-deregulation collapse of interregional air routes, and an effect of the policy of all major air companies using Moscow airports as their hubs for both domestic and international flights. The same situation of ongoing concentration of air traffic, especially international one in major airports is a feature of both US and Western European markets (Goetz, Vowels, 2009; Suau-Sanchez, Burghouwt, 2011).

Three following airports (Khabarovsk, Novosibirsk and Kaliningrad) have 30% lower air mobility than Moscow hinterland. In addition to the already mentioned remarkable results of the airports in the Russian North and Far East some other important geographical trends should be noted. The north of European Russia has unstable dynamics but relatively higher figures while the south of European Russia shows a higher growth rate despite the overall moderate values of air mobility. The Volga-Urals region combines low growth rates with moderate to low values of the indicator thanks to well-developed ground transportation and proximity to Moscow. The latter factor for a long period suppressed the progress of the now fast-developing Nizhniy Novgorod and Kazan airports. The airports of southern Siberia have relatively low figures of air mobility and diverse dynamics.

The grouping of airports based on the correlation matrix of their air mobility dynamics allowed describing three clusters (see Table 1) of airports in Russia. The first one can be called 'frontline cluster' and includes Moscow, St Petersburg, Yekaterinburg, Rostov-on-Don, Krasnodar, Perm, Kazan, Vladivostok and Novosibirsk as well as several loosely related pretenders. The core of the cluster consists of the airports of different geographical locations but almost all of them are located in focus cities with important interregional functions. For these airports, the size and relations with capitals have much more importance than their geographical location, and their air mobility dynamics follows the general trend of the country.

The second cluster can be called the 'resource-based one' as it includes the airports of regions whose economy depends on activities related to oil and gas extraction and processing, and metallurgy. The core of this cluster is formed by Ufa, Chelyabinsk, Omsk, Tyumen and Irkutsk. Air mobility here depends on the situation on the markets of oil, gas and metal products and now has relatively low growth rates in comparison to the mid-2000s booming years of high oil prices.

The third cluster is the smallest one and consists of the airports of the Komi Republic, Saratov, Ulan-Ude (the pretender) and Mineralnye Vody. The only common feature of these airports is their role in traditional recreational non-sea tourism (as origin or destination) and the long history of competition restrictions by a local air company. This cluster can be called the 'Soviet-tourist one'. It has very low air mobility that can be dramatically increased by airport upgrade and real service deregulation.

In Kazakhstan, the main issue is the competition between two capital cities and their airports. Air mobility analyses show that Astana has surpassed Almaty in 2007. Unlike many Russian airports both Kazakhstani airports now have high values of aviation mobility thanks to traditionally well-developed air transportation in the country where severe climate and vast distances give to it strong advantages over ground transportation. Astana in particular made the great progress in 2000s as at the beginning of the decade its hinterland had very low air mobility. The other specific feature of Kazakhstan is the relatively low influence of the 2008 crisis on passenger air traffic because the crisis hit the country earlier and was mostly of a financial rather than economic nature.

The demographic forecasts done during the research predict overall stabilisation of the size of population of Russia in the upcoming decades as it will slightly decrease to 140.56 million persons by 2030. The City of Moscow and Moscow region, as well as some regions of Southern Russia will top the list of population gainers while the regions of the Far East and some already heavily depopulated areas of the interior of European Russia will lose up to one third of their present inhabitants. The results for the hinterlands of Almaty and Astana in Kazakhstan are more impressive as Astana and its neighbouring region will double their population by 2030 while Almaty will experience 'only' 67% increase.

Before composing long-term trends based on demographic forecasts and air mobility historical data we should examine in detail the factors affecting air mobility and passenger traffic growth. As it was explained above, seven airports were taken for this study with different locations and regional economic structure. For this part of the research the modelling system and regional economic mid-term forecasts of Russian company Prognoz were applied and regression models were built. The research has revealed that investment in fixed assets and accumulated income of population are the strongest factors in forecasting air passenger traffic of an average airport in Russia (see Table 2). Moreover, investment in fixed assets prevails over income in most of the cases and this perfectly corresponds to the estimated 70% share of passengers travelling for business purposes in the overall air traffic.

Table 2. Details of regression modelling and forecasting of air traffic of several Russian airports

Airports	A	B	C	D
Barnaul	accumulated investment	0.838	0.32	0.38
Yekaterinburg	current investment	0.893	3.16	3.78
Anapa	people's income in Russia, output of steel	0.946	0.60	0.59
Vladivostok	Russian investment, Russian international trade turnover	0.943	1.27	1.64
Magadan	current people's income	0.797	0.28	0.33
Volgograd	accumulated investment	0.798	0.43	0.57
Chita	retail sales of non-food goods	0.753	0.19	0.24

Explanation: A – key factors revealed (constant prices); B – R2 value of the model; C – forecast for 2012, mln passengers; D – real data for 2012, mln passengers

Source: Author's calculation

However, some curious exceptions exist. The examination of passenger traffic of Anapa airport revealed its strongest relation to the state of Russian metallurgy. The obvious explanation is that Anapa for decades has been the sea resort for organised holidays for children and now such kind of activity exists mainly in Russian metallurgical and oil and gas cities which have a number of flights to Anapa. Metallurgical companies, however, are not as stable in their social expenditures as oil ones because these expenditures depend on the situation on the market of metals and more generally, on the output of crude steel in Russia. At the same time, Vladivostok airport passenger traffic depends on federal investment in the region, the volumes of international and local trade forming the other clear exception to the general trends.

Mid-term forecasts of passenger traffic through the selected seven airports indicates much slower growth or even decline of traffic because of the poor performance of the main economic indicators in these regions. The phenomenon of the ongoing growth of air traffic in Russia against the background of inert economic situation has been mentioned by aviation experts (Kramarenko, 2012) many times and, unlike the 1990s boom in international travelling after the disappearance of the Iron Curtain, it has no clear explanation. It may be seen as a temporary fluctuation; in fact correction began in 2012 with visibly slowed down progress in the selected airports.

Long-term forecasting air mobility and passenger traffic of Russian airports suggests more than triple increase of traffic by 2030 (346% to the value of 2011 for the sum of all 30 examined airports). However, for some airports, like those of Nizhniy Novgorod, Perm and Chelyabinsk, booming growth is expected while others, like Kemerovo and Barnaul, should prepare themselves for minimum increase of traffic mainly due to demographic reasons and poor historical data dynamics. Air mobility indicator for the hinterland of Moscow airports will increase to 4.3 from 1.9, and will remain the highest among non-northern airports of Russia. St Petersburg, Novosibirsk, Arkhangelsk and Krasnodar region will follow Moscow with air mobility indicator values of more than 3.5. The list of outsiders will remain almost unchanged despite doubling and tripling air mobility in in the regions of southern Volga-Urals and Caucasus (for details see Table 3).

Table 3. Annual passenger traffic of airports of Russian regions: historical data and forecasted data, millions

	1995	2000	2005	2010	2011	2015	2020	2025	2030
Airports of Moscow	20.25	16.97	29.61	51.04	56.45	80.81	112.73	141.33	164.60
St Petersburg	2.92	2.57	4.77	8.44	9.61	14.00	20.45	26.45	31.07
Airports of Krasnodar region		2.12	2.87	4.71	5.37	7.03	10.79	16.49	25.16
Nizhniy Novgorod	0.29	0.13	0.17	0.38	0.46	1.07	2.54	6.00	14.16
Yekaterinburg	1.32	0.85	1.47	2.75	3.36	4.21	6.37	9.28	12.89
Ufa	1.40	0.62	0.87	1.50	1.69	2.48	4.06	6.59	10.62
Rostov-on-Don	0.78	0.47	0.68	1.44	1.72	2.35	3.84	6.16	9.69
Novosibirsk	1.47	0.88	1.46	2.26	2.76	3.40	4.83	6.82	9.62
Samara	1.19	0.74	0.98	1.57	1.74	2.36	3.51	5.18	7.58
Airports of Tatarstan	0.41	0.21	0.48	1.23	1.52	2.91	5.20	6.88	7.56
Chelyabinsk	0.58	0.25	0.37	0.66	0.83	1.30	2.24	3.83	6.55
Vladivostok	0.78	0.52	0.85	1.26	1.46	1.96	2.95	4.41	6.54
Perm	0.40	0.18	0.32	0.75	0.87	1.49	2.63	3.92	4.92
Krasnoyarsk	1.57	1.00	1.53	1.69	2.17	2.43	3.06	3.81	4.72
Irkutsk	1.07	0.52	0.69	1.08	1.26	1.64	2.35	3.33	4.68
Mineralnye Vody	1.07	0.51	0.59	0.89	0.97	1.35	1.95	2.83	4.14
Khabarovsk	1.17	0.62	0.85	1.46	1.60	1.81	2.37	3.08	3.97
Tyumen	0.99	0.54	0.67	0.97	1.08	1.41	1.99	2.79	3.89
Arkhangelsk	0.39	0.19	0.33	0.64	0.76	0.95	1.50	2.35	3.65
Omsk	0.67	0.31	0.45	0.61	0.73	0.97	1.43	2.07	2.98
Airports of Komi	0.61	0.14	0.19	0.32	0.38	0.49	0.78	1.21	1.86
Voronezh	0.21	0.06	0.09	0.20	0.28	0.49	0.92	1.39	1.71
Chita	0.23	0.05	0.12	0.17	0.20	0.32	0.55	0.93	1.59
Kaliningrad	0.34	0.24	0.66	1.02	1.23	1.33	1.33	1.32	1.30
Tomsk	0.33	0.16	0.25	0.34	0.39	0.48	0.65	0.89	1.22
Petropavlovsk-Kamchatsky	0.54	0.28	0.41	0.51	0.55	0.63	0.77	0.93	1.11
Ulan-Ude	0.27	0.09	0.15	0.17	0.19	0.28	0.41	0.62	0.91
Volgograd	0.48	0.23	0.27	0.48	0.54	0.68	0.82	0.89	0.91
Murmansk	0.61	0.23	0.28	0.47	0.55	0.50	0.61	0.75	0.90
Yuzhno-Sakhalinsk	0.39	0.29	0.54	0.75	0.77	0.90	0.97	0.95	0.89
Astrakhan	0.09	0.11	0.11	0.33	0.35	0.49	0.69	0.82	0.87
Orenburg	0.34	0.15	0.20	0.34	0.44	0.55	0.71	0.81	0.85
Blagovechshensk	0.12	0.06	0.12	0.16	0.19	0.26	0.37	0.52	0.73
Saratov	0.29	0.15	0.16	0.22	0.25	0.29	0.38	0.50	0.64
Kemerovo and Novokuznetsk	0.40	0.15	0.37	0.44	0.48	0.53	0.56	0.55	0.54
Abakan	0.14	0.04	0.07	0.10	0.10	0.16	0.23	0.34	0.50
Magadan	0.32	0.13	0.17	0.24	0.28	0.27	0.33	0.39	0.46
Barnaul	0.22	0.14	0.24	0.32	0.36	0.40	0.42	0.41	0.40
Anadyr		0.05	0.10	0.08	0.08	0.08	0.08	0.08	0.08

Source: Association of airports of civil aviation 'Airport', 2012, airports' data, author's calculation

In Kazakhstan, both capital airports will increase their traffic by more than three times by 2030, but the overall air mobility of the population will remain lower (2.45-3.0) than in Moscow hinterland. Total passenger traffic of Almaty airport will reach the level of 15 mln passengers while Astana airport will serve more than 7 mln passengers in 2030. Almaty will once again surpass air mobility of Astana in 2024. These results can be taken to indicate that Almaty will remain the true economic capital of the country while Astana's potential of growth is limited.

While forecasts of passenger traffic growth provide significant business interest, geographical interpretation of these figures is important for reaching some conclusions about the uneven economic landscape and the competition between different territories. Several groups of territories can be determined taking into account two indicators: current air mobility and growth potential. The worst situation is in regions where air mobility is low and the potential of airport growth is relatively low, too. There are two such areas: the Volga region and the south of Middle Siberia.

There are multiple reasons for such pessimistic situation in Volga region, especially in its southern part. This territory was for decades one of the leaders in the economic development of the country and, during in Soviet times was the top manufacturer of passenger jets with aircraft plants in Samara, Saratov, Ulyanovsk and Kazan. However, since the middle of the 20th century the Volga region has been losing its position in the country. It has no clear and recognisable centre, but a number of competing cities instead; the oil and gas industry of the region, which propelled its development from 1943 to the 1960s, is now in stagnation while the manufacturing industry suffers from long-term post-Soviet depression. The situation is worsened by its proximity to the unstable regions of Caucasus and Central Asia, and by negative demographic trends with ongoing outflow of young people. Lack of investment attractiveness, relatively low incomes of people and absence of strong local airlines contribute to the slow progress of air transportation here.

The south of middle Siberia shares some features with the Volga regions but has some distinct traits, too. The region is heavily industrialised, with well-developed ferrous and non-ferrous metallurgy, and underdeveloped services and manufacturing industries.The industrial core of the region is formed by Abakan, Kemerovo and Novokuznetsk, and is surrounded by mountainous rural periphery. Lack of investment activity combined with extremely negative demographic trends provide relatively low forecast of growth for the airports of this region.

Several remote Russian regions will have almost no air traffic growth in the upcoming decades as their air mobility is already quite high and no further drivers of growth will be activated. These regions include: Kaliningrad, Sakhalin and Chukotka. At the same time Moscow, St Petersburg and some other large cities with interregional functions like Yekaterinburg, Krasnodar and Novosibirsk will remain growing leaders of air industry in at least the nearest 20 years.

The most interesting group is formed by regions with higher than average growth of passenger air traffic. There are several geographical areas where this rapid increase is expected: border regions of Eastern Siberia, the European Russian North, the south of European Russia and the Urals. In Eastern Siberia, there are multiple factors of passenger traffic growth. The first one is the active state support of air mobility increase and overcoming the geographical isolation of these regions with a system of subsidised flights. The second one are the growing economic relations with neighbouring China, and the third one is the overall revival of these territories in recent years due to the inflow of external investment in infrastructure projects and tourism development. The northern regions of Russia have some different reasons for the predicted boom in air transportation – they experience no significant inflow of investment or increase in people's income. Instead, they face serious demographic and economic challenges as their economies are mainly based on natural resources. But turning these territories into the 'classical' remote North means great progress of air transport as all other modes of transportation require either larger passenger traffic or the maintenance of infrastructure, and will decline gradually. The airports of the Urals have great perspectives thanks to the rapid progress in the main metropolitan areas of the region with fast developing services and construction activities. All of these cities (Perm, Ufa, and Chelyabinsk) have rich industrial past and present but the overall size of their economies and consumer demand are helping them to overcome the heavy burden of heavy industries and to develop into centres with diversified economies, like the frontline Russian inter-regional focus cities. Southern Russian airports of Rostov and Krasnodar will have much higher than average growth rates, too thanks to the boom of urbanisation in their hinterlands and positive demographic trends.

Table 4. Comparisons of air mobility and air mobility to GDP ratio for hinterlands of capital airports of some European and CIS countries

A	B	C	D	E
Denmark	37.7	Copenhagen	9.20	0.24
Iceland	39.2	Reykjavik	7.50	0.19
Latvia	18.3	Riga	2.36	0.13
Kazakhstan	13.9	Astana	1.56	0.11
Russia	17.7	Moscow	1.90	0.11
Moldova	3.4	Kishinev	0.34	0.10
Armenia	5.8	Yerevan	0.52	0.09
Albania	8.1	Tirana	0.64	0.08
Ukraine	7.4	Kiev	0.58	0.08
Estonia	21.7	Tallinn	1.70	0.08
Belgium	37.9	Brussels	2.80	0.07
Poland	20.6	Warsaw	1.35	0.07
Austria	42.4	Vienna	2.78	0.07
Germany	39.0	Berlin	2.55	0.07
Romania	12.8	Bucharest	0.76	0.06
Georgia	5.9	Tbilisi and Kutaisi	0.28	0.05
Lithuania	21.6	Vilnius and Kaunas	1.01	0.05
Serbia	10.4	Belgrade	0.47	0.05
Hungary	19.6	Budapest	0.86	0.04
Luxemburg	79.8	Luxemburg	3.33	0.04
Macedonia	10.6	Skopje	0.40	0.04
Belarus	15.6	Minsk	0.19	0.01

Explanation: A– Country; B– GDP (PPP) per capita, thousands USD, 2012; C– Airport hinterland; D – Air mobility in the hinterland; E– Air mobility to GDP (PPP) ratio

Source: IMF, airport's data, national censuses and population estimates

Theinternational comparison (see Table 4) of air mobility of the population of Russian regions provides some interesting results, too. Air mobility figures in the hinterlands of the capitals of high-income European countries range from 2–3 (Brussels, Luxemburg, Berlin, Vienna) to more than 7 (island capitals: Copenhagen and Reykjavik). Eastern European airports of Warsaw, Tallinn, Budapest and Bucharest have a high air mobility level (0.6–1.7) too, while indicator values for Kiev, Yerevan, Tirana and Belgrade can be classified as moderate. Airports of Minsk, Kishinev and Georgian cities are at the bottom of the list with low air mobility. This group could be expanded to include the airports of all Ukrainian cities except Kiev. The popular theory that GDP and passenger air traffic are closely related and that the first could be used for modelling the latter (Komaristy, 2006; Kramarenko, 2012) is not true. The air mobility of a country's capital to GDP (PPP) per capita ratio calculation provides interesting results. For most of the studied countries , this ratio is within the range 0.04–0.08 while higher values can be associated with geographical isolation (Copenhagen, Reykjavik) , strong high-distance relations with other territories (Yerevan, Kishinev, Moscow, Astana) or the presence of a hub-supporting air company

(Riga). Well-developed ground transportation, the moderate level of economic and social external activity contribute to lower ratio figures which can be found in most of the airports of European Russia, the Ukraine, Georgia, Macedonia and Belarus.

4. Conclusions

Aviation industry is a fast-growing sector of Russian economy with exceptional regional importance and clear geographical features. Thedynamics of air mobility in Russian regions clearly reflect the specialisation of local economies and individual characteristics of territories. However, in the last two decades the variance of air mobility dynamics of hinterlands of major Russian airports has decresed as a result of both centralisation of economy and air transportation. Two main clusters of airports can be described basing on air mobility dynamics: the frontline cluster of large airports in interregional centers whose dynamics generally follow the trend set by Moscow airports; and the resource cluster of smaller airports in regions with economies based on extraction and primary processing of natural resources.

Special econometric research provides reliable results and reveales that two economic indicators are the driving force of these changes, namely investment in fixed assets and income accumulated by people. At the same time, regression models predict a much smaller increase in air passenger traffic than real figures, supporting the thesis that the present abnormal growth of air transportation in the country has no clear explanation and can be considered a deviation from the general trend.

Long-term forecasts of air mobility growth in Russian airports predict tripling passenger traffic in Russian airports by 2030. However, some territories will experience booming growth, with the Urals, the south of Russia, Chinese border regions and the European North becoming leaders, while others, like the Volga region and the south of Middle Siberia remaining outsiders. In Kazakhstan, Almaty will regain its leadership in air mobility from Astana, whose potential of growth is limited.

There is no clear relation of GDP to air mobility as geographical factors and other local features have exceptional importance. Air mobility in Russian largest cities now is roughly the same as in Eastern European capitals but 2-4 times lower than in Western Europe, so the estimated figures of predicted growth look reasonable.

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