# The study of labor pendulum migration using big data processing technologies and the capabilities of the VKontakte social network

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**Abstract.** Official statistical data do not allow estimating the magnitude of labor pendulum migration in the context of regions and municipalities on a regular basis. The purpose of this research was to study the possibility of using open data of the VKontakte social network to identify and analyze labor pendulum migration on the example of Ekaterinburg and 12 satellite cities. Depersonalized information of users of the VKontakte social network and Rosstat data acted as empirical data. The research established a connection between the distance from the city of residence to Ekaterinburg and the proportion of citizens-users of the VKontakte network included in the process of pendulum labor migration. The analysis of incoming and outgoing flows of labor pendulum migration showed that despite significant differentiation by cities, in all cities the outgoing flow of labor migrants to Ekaterinburg exceeded the incoming one. The results of the research can be used in the analysis of the features, intensity and directions of pendulum migration for their consideration in the elaboration of strategic documents in the field of spatial development of territories. Further research by the authors will be aimed at improving the methodology for studying migration processes that occur between cities of millions and satellite cities, in order to identify agglomeration effects using big data technologies.

**Key words:** Pendulum migration; Spatial development; Population mobility; Social networks.

## 1 Introduction

The level and quality of life of the population living in different cities of Russia are not the same. (Monitoring the quality of life in Russia. https://clck.ru/34qXY3). The wide opportunities for employment, professional self-realization and higher income that take place in large and major cities make them attractive to residents of smaller settlements located within the boundaries of transport accessibility. This situation leads to the

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emergence of a pendulum migration. For some groups of the population, the largest cities have migration attractiveness, which is essentially formed at the level of an individual's subjective perception of the preference of a certain labor market (with its conditions and opportunities) relative to other markets under consideration.

Labor mobility is one of the most important characteristics of the labor market of a region or city. In this regard, it is urgent to research it, since the quantity and quality of the labor force is one of the key factors in the economic prosperity of the territory.

A significant number of papers have been devoted to the study of various aspects of migration. Russian and foreign authors study labor resources mobility and the peculiarities of population migration [1], individual migration factors, highlighting education, digitalization, employment and leisure [2-4], try to find a balance of migration flows [5], to investigate agglomeration effects [6, 7], carry out modeling of migration flows taking age into account [8], explore the professional mobility of the population as a form of social adaptation [9], analyze the socio-psychological aspects of migration [10], pendulum migration [10, 11] and more.

As for the pendulum migration, it not only affects the sphere of labor supply, but also social and geographical processes, and it is directly related to urbanism and the city economy. Thus, there is an interdisciplinary nature of this phenomenon. There is no single interpretation of this term in economic research, and there are no legally fixed signs of pendulum migration.

Pendulum migration is understood as:

- the phenomenon of territorial displacement of the population, which has a stable character and is not associated with the migrants residence change [12, 13],
- "making daily movements of the population to the place of work or study, but also migration for a longer period – from two to five days" [14],
- "daily shuttle movement of a part of the population – pendulum labor migrants – between places of work and residence located at a considerable distance from each other and in different economic entities (cities, districts, regions)" [15],
- "migration movements that are associated with work outside the place of permanent residence and are carried out with different frequency" [16].

The presented views allow us to assert that the following features distinguish pendulum migration from other types: regularity, repeatability, the fact of crossing the border of the settlement of permanent residence of the migrant and reverse return [Taking into account the digitalization of the economy, which contributes to the change of available forms of employment (for example, freelance, remote work, when labor migration becomes "hidden", since the employee movement in space does not occur, and the person "works" in another city or region). This type of migration requires a separate study]. In addition, it is possible to identify different reasons for the movement of people, which means that labor, cultural and leisure, educational pendulum migration can be distinguished.

In this study, pendulum migration was considered in terms of labor pendulum migration, the magnitude of which is primarily influenced by the factors, such as availability of jobs, wages, transport accessibility, differentiation of housing costs in small and large cities.

The peculiarity of the study of pendulum migration is that despite the evidence and "observability" of migration labor flows of the population, formal accounting is not conducted. Data on pendulum migration are obtained by statistical agencies only within the framework of population censuses, starting from 2002. However, the results of the population census give an idea only about labor pendulum migration in the whole country and by region [Results of the All-Russian Population Census in 2020. Rosstat. Available at: https://rosstat.gov.ru/vpn_popul (Accessed 10 May 2023)]. These data do not allow us to estimate the magnitude of labor pendulum migration in the context of municipalities and,

moreover, settlements, and also do not give an idea of other types of pendulum migration. This determines the need to search for sources of information.

To obtain such data, the research uses sociological surveys [17, 18], information about passenger transportation [19], data of mobile operators [20, 21], GIS-analysis ("Yandex.Traffic jams", "Yandex.Maps", satellite images) [22], population census materials, and information from social networks.

It is necessary to note the main problems associated with existing sources of information.

For all the informative nature of opinion polls/ interviews, a significant limitation is the high cost [23]. Among the limitations of the use of big data generated by GPS trackers or mobile operators, the lack of socio-demographic characteristics of migrants can be noted. Also, as a disadvantage, we can highlight the relative conditionality of the emerging data – for example, on the Yandex Map Constructor, the intensity takes into account all trips, so the busiest streets inside cities show a greater intensity than trips from nearby cities. The limitation of the widespread use of mobile operators' data is their high cost.

A significant part of the above limitations can be overcome by the use of social network data, for example, the VKontakte social network, which: a) can be obtained for free if appropriate competencies are available, b) allow you to form a socio-demographic portrait of people engaged in labor migration.

## 2 Materials and methods

Social networks have already become a part of a person's daily life. Since an increasing part of the population uses them daily for communication, data exchange, doing business, and so on. Information from social networks provides a rich source of data that can be used to answer a wide range of research questions from various disciplines [24]. At the same time, currently "the prevailing methods are sentiment and content analysis" [25], and online voices expressed in social networks are considered as qualitative data for researchers [26].

The Institute of Economics of the Ural Branch of the Russian Academy of Sciences involved in the preparation of a Bulletin dedicated to the million-plus cities of Russia is conducting a study of labor pendulum migration between them and satellite cities using big data processing technologies and the capabilities of the VKontakte social network.

At the first stage of the study, a list of satellite cities was formed for each million-plus city in Russia. For this purpose, the methodology used to determine the boundaries of agglomerations by mapping transport accessibility was applied [14].

To determine transport accessibility, isochrons were constructed – lines of equal time spent on overcoming space relative to specified points. In this study, the given points were a million-plus city and adjacent settlements. The boundaries of the isochron were determined by the physical distance of the satellite from the million-plus city at a distance of 60 km and transport accessibility of 1.5 hours by car. GIS Maps&Directions and Yandex Maps were used in the work. Using the Map&Directions service, circles with a radius of 60 km were drawn to search for possible satellite cities. With the help of Yandex Maps, routes were laid from satellite cities to a million-plus city, settlements were excluded, the path to which along highways is longer than 60 km and takes more than an hour and a half. As a result, a list was formed consisting of 14 city centers and 79, satellite settlements selected for the study of labor pendulum migration.

At the next stage, the computer program developed by the research group "Obtaining data on labor migration based on the profiles of users of the VKontakte social network" (certificate number: 2023619437) was used. The program contains tools for creating requests to the VKontakte API, receiving and saving data sent to the API in a structured format in the form of CSV. The program allows you to get the results of the analysis in the

"Career" section in an aggregated form. It provides structured data about the respondent's city of work, who indicated the city specified for the analysis as the place of residence. Thus, as part of the study for the period March-April 2023, depersonalized data of about 9.1 million users, living in 93 localities, were analyzed. Of these, over 390 thousand users indicated their place of work, which made it possible to conduct a large-scale study of labor migration.

# 3 Research results

The results of the study are presented on the example of one million-plus city of Ekaterinburg. The database includes information obtained from the VKontakte social network, to which statistical information on the population aged 14–74 years has been added [This category is limited from 14 years old – the age limits of users of the VKontakte social network of cities / settlements, up to 74 years old – taking into account the classification of the World Health Organization as the most active able-bodied part of the population].

**Table 1.** Initial data on the satellite cities of Ekaterinburg.

| City | In1 | In2 | In3 | In4 | In5 | In6 |
|---|---|---|---|---|---|---|
| Berezovsky | 24,8 | 751 | 66,3 | 20,5 | 16 | 59,844 |
| Upper Pyshma | 27,7 | 1,027 | 70,8 | 21,5 | 17 | 69,709 |
| Sredneuralsk | 27,2 | 247 | 61,5 | 19,8 | 25 | 19,753 |
| Aramil | 34,6 | 288 | 62,2 | 26,7 | 26 | 14,738 |
| Upper Dubrovo | 10,0 | 32 | 53,1 | 28,1 | 34 | 3,879 |
| Sysert | 15,6 | 362 | 78,7 | 12,4 | 46 | 48,509 |
| Pervouralsk | 27,8 | 1,929 | 82,9 | 10,5 | 46 | 106,818 |
| Revda | 40,0 | 866 | 79,6 | 12,2 | 50 | 48,415 |
| Zarechny | 37,5 | 551 | 79,5 | 11,4 | 54 | 25,223 |
| Beloyarsky | 6,1 | 90 | 67,8 | 15,6 | 54 | 25,806 |
| Polevskoy | 43,9 | 1,058 | 84,4 | 8,5 | 59 | 51,159 |
| Degtyarsk | 30,2 | 137 | 63,5 | 18,2 | 59 | 11,677 |

Note:

In1 is Number of users-residents of the city, % of the population 14-74 years old;

In2 is the number of users who indicated their place of work, persons;

In3 is the share of users who indicated the city of residence as their place of work, % of the total number of those who indicated the place of work;

In4 is the share of users who indicated Ekaterinburg as their place of work, % of the total number of those who indicated their place of work;

In5 is Distance from Ekaterinburg km;

In6 is the total population of 14-74 years for 2022, persons. Calculated on the basis of data from the "Rosstat Municipal Indicators Database" Available at: https://rosstat.gov.ru/storage/mediabank/Munst.htm (Accessed 20 March 2023).

The data in Table 1 show that among the residents of these municipalities aged 14 to 74, VKontakte users are on average 27.1%, the minimum coverage is observed in Beloyarsk – 6.1%, the maximum – in Polevskoy (43.9%). This indicates a significant involvement of the population in social networks. However, not all of them give information about their place of work. In the studied cities, the share of users who indicated the city where a person works is about 5% of the number registered on the VKontakte social network in the corresponding city.

Most of the citizens-users of the social network selected for the analysis of the satellite cities of Ekaterinburg, work in the city of residence (column 4 of Table 1, on average – 70.8% of users). The maximum share is observed in Polevskoy (84.4%), the minimum – 53.1% is recorded in Upper Dubrovo. Examining the labor pendulum migration of satellite cities, we note that on average about 17.1% of users indicated Ekaterinburg as their place of work.

The study clearly shows that there is a connection between the distance from the city of residence to Ekaterinburg and the proportion of citizens-users of the VKontakte network included in the process of pendulum labor migration (Fig. 1). Satellite cities were divided into two groups, which can be observed in the figure.

Not only the proximity of cities, but also transport, territorial connectivity are of great importance for the formation of socio-economic and migration relationships between a million-plus city and satellite cities [28].
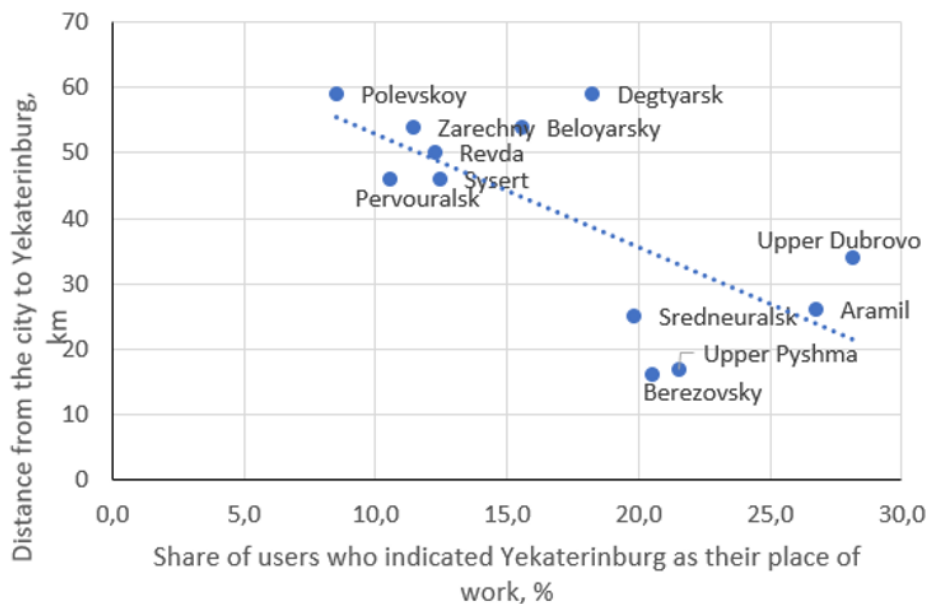


**Fig. 1.** The ratio of the proportion of citizens-VKontakte users working in Ekaterinburg and the distance from the city of residence to Ekaterinburg.

Of additional interest was the analysis of incoming and outgoing flows associated with labor pendulum migration.

The absolute number of users living in different cities traveling to work in Ekaterinburg and Ekaterinburg residents entering satellite cities to work is shown in Fig. 2.
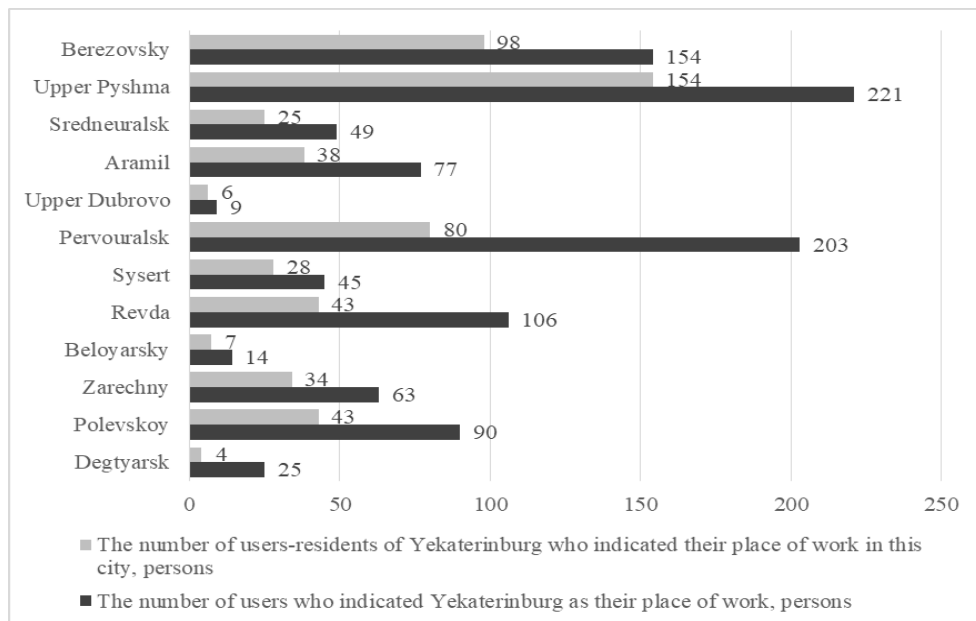
**Fig. 2.** Incoming and outgoing flows of labor migration in the satellite cities of Ekaterinburg.

Bar charts allow us to compare the volume of incoming (gray) and outgoing (black) flows of labor pendulum migration by the satellite cities of Ekaterinburg. There is a significant differentiation by city, but in all cities the outgoing flow exceeds the incoming one. Considering that among the most frequent factors causing labor migration, the expectation of an increase in income, the importance of professional self-realization, wider employment opportunities are noted, it is obvious that the city of a million people looks more attractive for residents of satellite cities by these parameters.

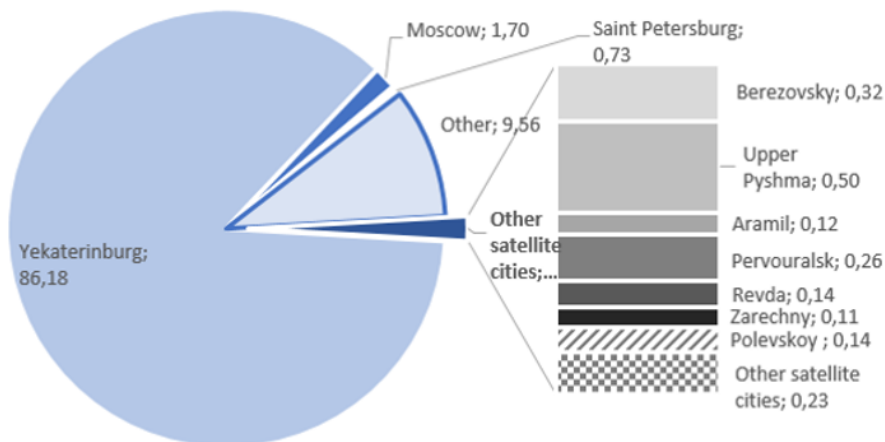The study of labor migration of Ekaterinburg residents revealed the following features (Fig. 3).



**Fig. 3.** Distribution of VKontakte users – residents of Ekaterinburg by city of work, %.

VKontakte users living in Ekaterinburg indicated 825 localities as the city of work: Ekaterinburg accounts for the main share (86.2%), Moscow (1.7%) and St. Petersburg (0.7%) occupy the second and third places, respectively. Ekaterinburg's 12 satellite cities account for about 1.8%, while other cities account for 9.6%. The top 20 localities in the "Other" category include 8 large cities of the Sverdlovsk region (Nizhny Tagil, Novouralsk, Kamensk-Uralsky, Asbest, Sukhoi Log, Lesnoy, Krasnoufimsk, Artemovsky), 7 million-plus cities (Chelyabinsk, Perm, Ufa, Novosibirsk, Krasnodar, Omsk, Kazan), 2 neighboring regional centers (Tyumen, Kurgan), the largest industrial and cultural center of the city of Khanty-Mansi Autonomous Okrug – Surgut, as well as two foreign cities – Kiev and Los Angeles. Thus, the outgoing labor migration flows of Ekaterinburg are very wide, diverse, and the share of satellite cities in them is minimal. The cities that "attract" labor pendulum migrants are large, developed cities. It should be noted that the sufficient remoteness of these cities does not allow us to speak unambiguously about the nature of pendulum migration (it can be both longer in time than labor pendulum migration to nearby cities, and "virtual" when a person works remotely, but is officially employed not in the city of residence). Clarification of these features requires additional research.

## 4 Conclusion

The conducted research shows that in a situation of restrictions on official statistical data on pendulum migration in the context of municipalities, the VKontakte social network is an affordable way to collect data that allows one to get an idea of the directions, nature and intensity of incoming and outgoing flows of pendulum migrants taking into account that users provide a wider set of data in the social network, this allows us to explore other types of pendulum migration (cultural and leisure, recreational, educational, and others).

The study of pendulum migration can be used to assess the need to expand and modernize the transport infrastructure, which, in turn, will contribute to increasing the level of economic connectivity of the territory of the Russian Federation, determining the spatial framework of the territories.

Also note that in the approved in February 2019 Spatial development strategies of the Russian Federation for the period up to 2025 agglomerations, mineral resources and agro-industrial centers are indicated in the priority of development [Decree of the Government of the Russian Federation dated 13.02.2019 No. 207-r (ed. from 30.09.2022) "On approval of the Spatial Development Strategy of the Russian Federation for the period up to 2025". Available at: https://clck.ru/35KfVF (Accessed 10 May 2023)]. Pendulum migration is attributed to the main qualitative signs of the formation of urban agglomerations, and, consequently, a methodological approach based on the use of big data technologies obtained from social networks can be applied to analyze the real boundaries of agglomerations, which may differ from the generally accepted ones.

The results obtained by us are correct within the time period under study and the methodological approaches used. The research revealed limitations: not all the nuances of labor pendulum migration can be identified only on the basis of social media data. The use, together with the analysis of social media data, for example, information on passenger transportation (taking into account personal and public transport), would give a more complete picture of the transport connectivity of territories and transport accessibility for the population. It is advisable to use the capabilities of the VKontakte social network in research to obtain initial information, and then clarify the most interesting or unexpected data for research by using additional sources of information.

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