

The economic and mathematical analysis of migration of employable population as a factor of national modernization in crisis

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Abstract

The methodical approach presented in the article allows for an unbiased analysis of the complex migratory processes that take place in Ukraine due to the influence of social, economic and financial indicators. The article offers a reliable analysis of the migratory processes, applying the differential logistic population model in order to clarify the effect of labour migration on the productive ability of the economy. The authors investigate the factors that induce a human person to migrate, and show that globalization affects international mobility.

Keywords: migration, migration flows, relocation, logistic population model, differential equations

1. Introduction

Modernisation is a synonym to all process improvements of a society. It is a phenomenon closely associated with the territorial movement of population. Migration occurs because of geographical disproportions in demand and supply of labour. Where labour force is scarce, earnings are higher. In the regions where labour is plenty, earnings are lower or insignificant. Migration provides the opportunity to improve material well being and wealth of humans. When people move into higher income regions, capital flows occur towards the reverse direction or towards areas where labour force is cheap.

Migration mostly arises from countries that fall behind in modernisation. Modernisation appears to be extraordinarily destructive to some countries. The more modern a country, the cheaper immigrant labour pours in. In modernized countries, societies are quickly transformed. Traditional forms of employment disappear. The modernized country adopts higher and stricter standards for bank

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loans, credit lines etc. Thus, many local people do not qualify for loans to start a new business. Higher risk insurance standards also have negative effects. This lack of opportunity forces people from modernized countries to migrate elsewhere.

However, it should be noted that the positive influence of migration on development is doubtful. Surplus labour force from the less developed countries is absorbed by the international labour market, the modernized countries absorbing most of the cheap labour. Modernized countries' businesses import cheap workers to lower their expenses. Also, a glut of cheap labour creates a reserve pool of labour. Migration deepens global contradictions, and subordination to rich countries by poor countries occurs. Thus migration does not assist in the development of poor countries. It deepens inequality and thus halts the modernisation of less developed countries.

The aim of this advanced scientific work is to improve methodical-theoretic approaches of prognostication of migratory processes with the possibility to completely use the potential benefit of migration for the modernisation of the state by simultaneously minimizing the socio-economic problems imposed by migration.

In order to achieve the article's goal, the authors' task is: to investigate the economic essence and structure of migration, propose a logistic population model based on differential equations so as to intensify the most possible positive and to reduce the negative influences of migration on the processes of modernisation of the country.

2. The main research

The modern interpretation of migration is premised by the fact that the process is accompanied by mighty streams of standards from migrants, that work in developed countries, to the families in the countries that develop. It contributes to the reduction of poverty by bringing in capital to finance development and to spread modern methods of production and better way's of life. Facts show that migration assists modernisation at a global scale. From compiled results, the increase of quantity of migrants by 8% will provide a global assets increase of 0.6% in the poor countries. For rich countries, an increase in quantity by 1.8% will provide an increase in assets by 0.4% (UN, 2014).

Over a long period, in terms of world influence of migration on modernisation, the effect is, on the whole, positive. However, for an individual country, over a short time, this conclusion is not conclusive. So, in terms of aging population and deficiency of workers, migration has positive effects on the recipient country but loss of population in the donor country adversely affects the latter. The arrival of skilled employees from donor countries enable the modernization of recipient countries. The brain drain from donor countries negatively affects them.

At a macro level, the estimation of the effects of migration is quite conclusive. The receipt of higher quality services provided by the workers from donor countries helps richer countries improve their lives, get better education, have access to better medical services, as well as to better cultural services. At the same time, not every worker has benefits from migration. It all depends on the desire, potential and talent of the migrating worker. Therefore, although migration is generally beneficial to donor workers, not every donor worker benefits from it.

The analysis of migration as a contributing factor to modernisation in Ukraine envisages the use of a paradigm. First, taking into account the urgent need for modernisation in the country, it is essential to consider the state and value of modern migrations and their direct consequences. Secondly, Ukraine is at the same time the country of origin, transit and setting of migrants. Unfortunately, we must admit that in the case of modern Ukraine, the most pronounced factor is the ebb of population. The principal reason is the temporary halt on reforms that provide economic revival. In 2001, the GDP of Ukraine was only 40.8% of that in 1990. The economic growth in the first years of the 21st century resulted in 2008 reaching only 74.1% of this level (Vasilchenko and Grinenko, 2005). With the beginning of the financial and economic crisis, the indices of height of GDP reached negative values. Economic confusions were accompanied by a fall in population levels and an increase in unemployment. At the end of 1990, there was an 11-12% drop in the working population, and it got even worse; in 2010, it reached 8.8% in the IOL methodology (international labour organization). There were 1.7 million unemployed citizens (State Statistics Service of Ukraine, 2010). Data shows that emigration from Ukraine took place to obtain permanent residency abroad via employment (Lutz, Sanderson and Scherbov, 2010).

According to UN Department of Population data, 6.6 million Ukrainians live abroad. This is approximately 14.4% of the current population of Ukraine;. Most emigrants went to Mexico, India, Russia and China. Ukraine is № 5 on the list of the most important emigrant donors to the world (State Statistics Service of Ukraine, 2015). Loss of labour and intellect in Ukraine is mostly due to emigration. During 2014-2015, massive emigration from Ukraine took place. It continues until today as the most significant social migration stream. On top of it, the war has invoked the transformation of the available labour. Some migrants gave up the idea of returning home; instead, they transported their families abroad. As a result of mass emigration and active voice of this migration abroad, Ukraine got the “Mexico of Europe” nickname. Thus, the influence of migration on the modernisation of a country forms the basis in examining the country of origin especially when large masses of emigration impact on the international labour pool. The basic impact of modernisation is caused by migrants’ earning abroad – and the money is sent back to the donor country by the emigrants. As global migrations intensified, the volume of private financial transactions grew and became the largest international financial stream. By World Bank estimates, in

2010, out of a total volume of \$440 million, \$325 million was sent to developing countries. The highest receipt of money from abroad was in India (\$55 million), China (\$51 million), Mexico (\$22.6 million), Philippines (\$21.3billion). This is information provided by regular informal channels. There were also very large sums of money sent through illegal channels. In Ukraine alone, \$5 million illegal money was received per year from the USA. In Eastern Europe and Central Asian regions, the volume of money received were highest in Russia and Serbia (World Bank, 2015).

Unlike streams of foreign direct investments or international help, the volumes of transactions from emigrants do not depend on international financial institutions or investors. Also, transactions do not flow at a steady stream. When conditions in donor countries worsen, countercyclical influences are observed: e.g. the help received by families from migrants in Ukraine has increased. While World Bank data showed a marked reduction in volume of this financial stream in 2009, estimated at 5.5%, actually, in 2010, the figure increased to 6% (State Statistics Service of Ukraine, 2015). The same trend was seen in 2014-2015 - the emigrants living in Europe sent \$109.4 million to Ukraine.

Thus, the money received from emigrants living abroad has become the most important source of infusion into the Ukrainian economy. This confirms the countercyclical trend explained earlier. These foreign transactions have a positive impact on the balance of payments, reduce payment deficit and, finally, come across as an important import source. These transactions are effective instruments in the fight against poverty, because money goes straight to the people who receive them.

A research conducted in 71 developing countries showed that a 10% increase of transactions per capita significantly reduced poverty by 3.5% amongst people living in poverty (World Bank, 2015). Thus, these direct transactions obviate the need for the state to provide financial help to poor people.

Money earned abroad by emigrants helps to improve living standards, quality of homes, payment of education fees and medical services of people living in donor countries. This phenomenon was proved in an audit by Ukraine Government Department of Statistics; the 2014-2015 period showed that except for daily consumption, migrant earnings were spent on the improvement of domestic living conditions, e.g. purchase of residence buildings, apartment repairs, purchase of durable goods, finance education and medical treatment of family members. Due to these transactions, many small business projects were self-financed. The same businesses could never qualify for bank loans on their own.

Migrants mainly invested in business enterprises: cafes, restaurants, hotels etc. Though the investment of this money waste a rather low extent, the Ukraine Government Department of Statistics showed that, in 2015, investment by emigrant workers was 1.5 times higher than regular individual citizens' as self-employed and one third higher than corporate private enterprises (State Statistics Service of Ukraine, 2015). Migrants are businessmen who not only created jobs

for themselves or their family members but also hired, on the average, 5 employees. Had it not been for this infusion of capital, unemployment in Ukraine in the 2014-2015 period would have been 1.6 time higher.

Therefore, these transactions from migrants have considerable social results. They also promote economic development. By their support and influence, the banking system also develops and improves. Even on the consumption side, they help to increase real consumption which stimulates production. This is calculated in terms of the country origin of the consumer goods. Every 1 dollar was translated into the production of 2 dollars (World Bank, 2015; Baldwin-Edwards, 2015).

This effect is called the “five T” formula: transfers, transport, telecommunications, tourism, trade (Moré, 2005). In fact, the contacts with relatives in donor countries and travel by emigrants positively impact on the development of tourism, telecommunication, transportation etc. Migrants’ demand for the so-called “nostalgic” goods (usual foodstuffs, printed materials, audio, video and media products and others like that) increases exports to their adopted countries. This increases production in home countries. The import of native fashionable products and goods to the recipient countries as a result of the increasing level of the products in the native countries increases. Consequently, the volume of international trade increases.

The animated effect of earnings of migrants on the economy of Ukraine can be illustrated by the example of the construction industry. Considerable housing investments are needed to support the growing numbers of workers in the production companies of donor countries. Also, the emigrant needs of having new house or improve the existing ones in the home countries have grown. The indices exceeded one level considerably. As a result of the construction industry growth, the demand for building materials, fixtures, appliances, furniture and appurtenances also increases growth in these satellite industries.

Except the standard ones, there are also social transfers, ideas, looks (relation to democracy, healthy way of life, gender roles, human rights and self-organization of the civil society), models of behaviour and interpersonal copulas that can be used as a social capital, what migrants bring to their motherland.

With respect to the modernizations of emigrants’ country of origin as well as to social transfers, let us consider the example of India. Highly skilled American Indians that worked as managers of multinational American corporations assisted the development of hi-tech manufacturing industry in India. 19 to 20 of the leading Indian companies that produce hardware and software were created or managed by migrants. The opening of new industries created 400,000 new jobs. The new workplaces generated profits of more than \$6 million per year. India transformed from an industry exporting technical and scientific human talent to a country exporting hi-tech commodities and services (Lutz, Sanderson and Scherbov, 2010).

The influence of migrant transfers on the development of the donor country is not always positive. Yes, new ideas and goods sometimes result in the loss of national and traditional cultural values, goods and services. Sometimes, the price of goods increases, which leads to high inflation. In particular, in recent years, Ukraine real estate prices have inflated many folds.

Emigration also generates certain warnings regarding the reduction of poverty in donor countries. In fact, the poorest layers of society and population do not succeed. Although the earnings of migrants undoubtedly, assist the improvement of life expectancy, sometimes, fracture lines are created amongst members of the same family. Some members become rich overnight, others continue to remain poor. Sponsorship of families of migrants from abroad occasionally results in exporting of labour to recipient countries. This creates a labour vacuum in some regions e.g. Ternopil Region, Zakarpatya. In these regions, there was not enough local labour to provide for the needs of the growing construction industry, so labour had to be imported from outside Ukraine.

The deficiency of labour in a donor country is not strictly a result of mass emigration. Age, education, quality of people emigrating contribute in more significant ways. During 2013 and 2015, emigration from Ukraine resulted in 0.9% loss of population. It is interesting to note which age groups contributed more to emigration. Between ages 25 to 29, 6.8%, between ages 30 to 34, it was 4.9%, between ages 30 to 34 it was 2.1%. We note that younger people migrated more than older people but the older people who were more actively involved commercially emigrated less. Children or seniors who were not part of the active labour force were left behind (Nassar, 2014).

The most serious negative effect of emigration in a donor country is the “brain drain” or loss of intellectual, skilled and highly professional people. During 2013 and 2015, Ukraine lost 15-20% of this segment of labour force. (Newland, 2015). It also implies the loss of commercial investment opportunities by this segment of the labour force and the ability by the donor country to not reap the benefits of their investments. The donor country also loses the tax benefits that would have derived from the high incomes of this labour force. However, there is a silver lining to this adversity. The vacuum created by the “brain drain” provides opportunities to less skilled people to rise to the occasion, improve their job skills and go after these well paid jobs. Also, the exchange of technical information between the “brain drain” people and the donor country opens up. This leads to new jobs, e.g. translators, collaborators, middlemen etc. Also, sometimes, the “brain drain” people return to the donor country. When that happens, they energize the marketplace with new ideas, new technologies, scientific and technical collaborations and new capital investments. Sometimes, even the temporary return of the “brain drain” people provides “fuel” to the economy. Convincing examples of this phenomenon are China, Taiwan, Malaysia and South Korea.

In summary, although there are some fringe benefits of emigration, there are significantly larger losses to the donor country (see Table 1). The benefits of international migration are sometimes lost or not broadcasted. The weak correlation between migration and development is explained by many reasons. Most of them lie hidden in the donor country. Some are mistrust of government and power mongers, corruption, self-will of bureaucracy, negative dynamics of transformations and absence of infrastructure. Part of the blame must also be taken on by recipient countries: exploitation of migrants by means of low wages and denial of human rights.

Table 1. Positive and negative impacts of migration processes of modernization

Positive impacts	Negative impacts
Rising efficiency of the global economy	Loss of skilled workers and absence of the quality of work performed by them
Poverty resistance	Possible increase in income inequality
Reducing the pressure on the labor market	Risk of inflationary impact of remittances
Inflow of foreign currency	Low productivity growth work due to deterioration of quality labor
Increase investment in human capital	Loss of expenditure on education and training migrants
Inflow of new knowledge, technologies, business relationships, social capital from the border	Depending on the risk of transfers, cash recipients' unwillingness to work, stereotyping that an increase in the level of life can only be achieved by migration
The development of international trade	Loss of tax revenue
The spread of values and norms of civil society	Negative changes in the psychology of migrants due to long illegal stays abroad

Source: own representation

Globalisation has come to stay. It has induced international mobility and it has significantly impacted on the global economic system. Therefore, we should take advantage of this phenomenon to help modernize the world. All countries must work together to improve migratory policies. Also, countries need to establish migration policies. Donor countries must first establish migration policies and lay down firm rules and methods for migration so as to protect the human rights of migration.

The mathematical modelling of human migration has the goal of monitoring and predicting the critical rate of employable population migration. Differential equations widely used to investigate different problems in the economy, to shape the dynamics of the small businesses, are so-called basic differential equation of neoclassical growth theory.

Mathematical modelling is based on differential calculus that allows investigating the problem with regard to different conditions of dynamic economic situation in the country. The Malthusian Growth Model was written by Thomas Malthus in 1798 and the other approach is more precise about what the logistic population model is (Malthus, 2000). This model concerns the population and assumes that the relative growth rate decreases linearly as the population increases. It takes into account the fact that populations cannot grow exponentially forever because we have limited resources. This differential equation is going to be modified to investigate the employable population migration. The solutions of the differential model, constant throughout the whole period and known as equilibrium solutions, are the most interesting

The Malthusian Growth Model is based on an essay written by Thomas Malthus in 1798, in which he said: "Population, when unchecked, increases in a geometrical ratio". It should be noted that, at a certain stage of migration, the Malthusian growth model might be applied successfully.

$$\frac{dP}{dt} = kP, \quad (1)$$

P – number of the employable population;

k – growth rate of the employable population;

t – time in years.

Sometimes it is called a simple exponential growth model based on a constant rate k and $P(t)$:

$$P(t) = P_0 e^{kt}, \quad (2)$$

$P_0 = P(0)$ - initial number of employable population.

This model is often referred to the exponential law. It is widely regarded in the field of population ecology as the first principle of population dynamics. It is generally acknowledged that the simplicity of the model makes it useful for short-term predictions when population growth is unchecked.

The other approach is more precise about what the logistic population model is (Blanchard and Cummings, 2015). This model assumes that the relative growth rate decreases linearly as the population increases. It takes into account the fact that populations cannot grow exponentially forever because we have limited resources.

The growth rate of a population depends on the population itself. Once a population reaches a certain point, the growth rate will start reducing, often drastically. This much more realistic model of population growth is given by the logistic equation:

$$\frac{dP}{dt} = kP \left(1 - \frac{P}{N} \right), \quad (3)$$

Therefore, t , as usual, is going to be time in years, but it can be measured in the other convenient units;

P – number of the employable population;
 k – growth rate of the employable population;
 N – carrying capacity.

This differential equation is going to be modified to count for the immigration of employable population. Assuming that the immigrants leave at a constant rate, a parameter C , which is going to be equal to the positive constant rate of immigration, is introduced. This is a new modified logistic model with constant of immigration:

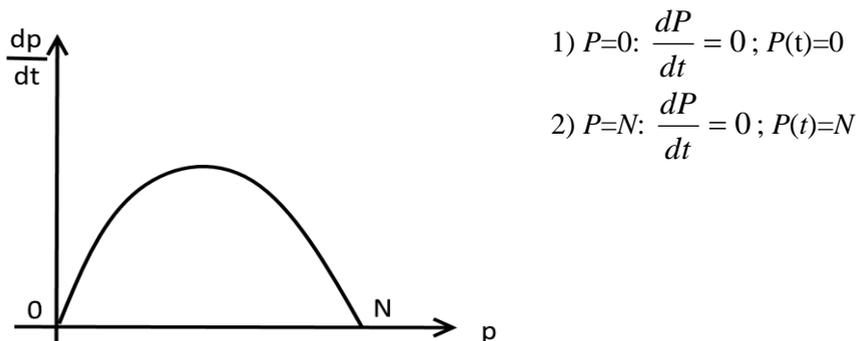
$$\frac{dP}{dt} = kP\left(1 - \frac{P}{N}\right) - C, \quad (4)$$

C – positive constant rate of immigration;

It is important to realize that k and N are fixed parameters, C is going to be the varied parameter in this model.

On the right side of the equality, the quadratic expression is represented. If $C=0$, the graph of quadratic function intersect P -axis in the points 0 and N (Figure 1):

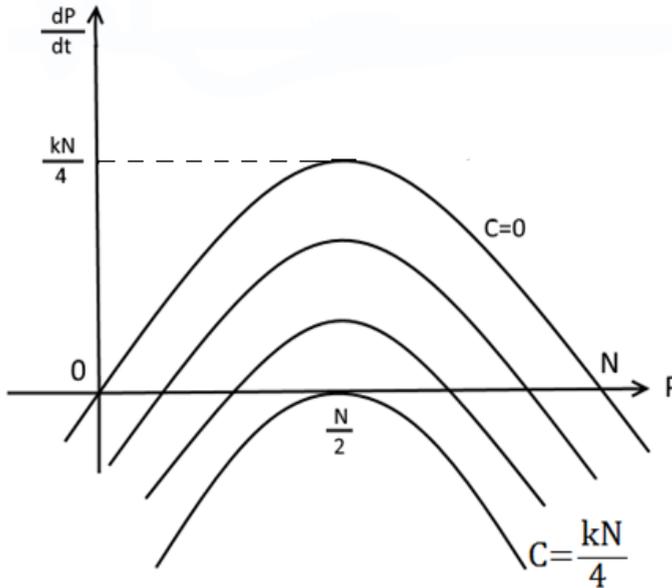
Figure 1. The graph of modified logistic model with the immigration constant $C=0$



Source: own representation

Therefore, two equilibrium points exist at 0 and N . Between these two equilibrium points dP/dt is greater than 0; and so, the solutions are going to be increasing. Beyond the interval $(0, N)$, dP/dt is negative and the solutions are going to be decreasing. The simple investigation of the function shows the change of the graph, which depends on the value of C (Figure 2):

Figure 2. The graph of the modified logistic model when the constant of immigration C takes different values



Source: own representation

When parameter C grows from 0 to $kN/4$, the equilibrium points move closer to the centre. In between the two equilibrium points, dP/dt is positive, so solutions would be increasing, and outside the equilibrium points, the solutions will be decreasing. When parameter C goes to the value $kN/4$, very different behaviour of the function can be observed. The parabola ends up being tangent to the P -axis and there is only one equilibrium point which is called the bifurcation point, and that is at $N/2$. Beyond that point, dP/dt is negative, and so the solutions will be decreasing in any case.

At the equilibrium point $N/2$ $dP/dt = 0$, so the modified logistic model turns into quadratic equation:

$$C = kP \left(1 - \frac{P}{N} \right), \quad (5)$$

This result has a quite interesting interpretation concerning immigration over a long time. When the parameter $C < kN/4$, the employable population is enough and this is a stable situation with a modest amount of immigration. However, as the value of C increases, the quantity of employable population decreases up to a certain point when parameter C passes the bifurcation value. In that case, if the quantity of

immigrants still increases, the quantity of the employable population decreases and the economic system is going to be in trouble.

According to the statistic information (Ministry of Finance of Ukraine about unemployment rate from 2012 until 2015), the total population and the employable population of Ukraine is presented (in thousands) in Table 2.

Table 2. The population and the employable population of Ukraine in dynamics 2012-2015

Year	The population	The employable population
2012	45553,0	20393,5
2013	45426,2	20478,2
2014	42928,9	19035,2
2015	42760,5	17396,0

Source: Ministry of Finance of Ukraine

The parameter of the mathematical model growth rate $k = 0.949$ is defined from this statistics and the acceptable quantity of emigrants (bifurcation point) is presented in Table 3.

Table 3. Acceptable quantity of emigrants (bifurcation point) in dynamics 2012-2015

Year	The bifurcation value of the quantity of emigrants (C)(in thousands)
2012	4839,33
2013	4859,43
2014	4517,01
2015	4128,03

Source: own representation

Comparing the bifurcation value C for 2012 with the real quantity of emigrants in this year (6.5 – 8 million) (Independent News Bureau, 2015), it may be said that the bifurcation point has been passed and that the Ukrainian economy needs some stabilization efforts which should be applied to rebound the situation.

3. Conclusions

The methodical mathematical approach based on the differential logistic population model presented in the article shows an effect of leaving employable people on the general rehabilitation of productive forces of the country. Migratory statistics and analysis represent a pre-condition for scientific approaches. It can be effective in the active collaboration between the state and immigrants, in the development of permanent dialogue with them. Thus, the modernization of economic and social conditions focused on modern world achievements,

purposeful actions of the state on providing modern social and economic defense can attract native and international productive forces to Ukrainian industry.

In order to make good use of development migration, it is necessary to have a purposeful activity, and at least four basic directions, such as: stimulation of money transfer to the home country by migrants abroad; counteraction to the negative consequences of “brain drain”; encouragement of migrants to return to their home country; development of effective collaboration with migrant communities abroad.

The success of migratory policies which can be focused on the country modernisation foremost depends on: the achievement of knowledge related to the clear aims related to this aspect; the amount of immigrants; the structure; the dynamics of migratory streams and their influence on the socio-economic situation of a country. The pre-condition of making scientifically-reasonable approaches is developed by the migratory statistics and migratory researches.

References

- Baldwin-Edwards, M. (2015), *Migration in the Middle East and in the Mediterranean*, A Regional Study prepared for the Global Commission on International Migration, *Mediterranean Migration Observatory*, Athens: Routledge.
- Blanchard, P. and Cummings, P. (2015), *BUx: Math226.1x Introduction to Differential Equations*, retrieved from <https://courses.edx.org/courses/BUx/Math226.1x/1T2015/info>
- Independent News Bureau (2015), *Report of the fact that abroad, left a third of the working population of Ukraine*, Kyiv, retrieved from <http://nbnews.com.ua/ru/tema/91803>
- Lutz, W., Sanderson, W. and Scherbov S. (2010), The coming acceleration of global population ageing, *Nature*, No. 451, pp. 716–719.
- Martin, S. (2015), *Remittance Flows and Impact*, The Regional Conference on Remittances as a Development Tool, organized by the Multilateral Investment Fund and the Inter-American Development Bank, Washington, D.C.: Routledge.
- Malthus, T. (2000), *An Essay on the Principle of Population*, Library of Economics (description), Liberty Fund, Inc., retrieved from <http://www.econlib.org/library/Malthus/malPopCover.html>
- Ministry of Finance of Ukraine (2015), *Report of unemployment rate in Ukraine in 2012 until 2015*, Kyiv, retrieved from <http://index.minfin.com.ua/people/unemploy.php>
- Moré, I. (2005), *Emigrant's Remittances in Spain: An Opportunity for Action Abroad*, Elcano Royal Institute, Madrid: Routledge.
- Nassar, H. (2014), *Migration, Transfers and Development in EU*, *CARIM Research Report*, European University Institute, Robert Schuman Center for Advanced Studies, Florence: Routledge.

- Newland, K. (2015), *Migration as a Factor in Development and Poverty Reduction*, retrieved from <http://www.migrationinformation.org/feature/display.cfm?ID=136>
- State Statistics Service of Ukraine (2010), *Report of SSSU*, Kyiv, retrieved from <http://www.ukrstat.gov.ua>
- State Statistics Service of Ukraine (2014), *Report of SSSU*, Kyiv, retrieved from <http://www.ukrstat.gov.ua>
- State Statistics Service of Ukraine (2015), *Report of SSSU*, Kyiv, retrieved from <http://www.ukrstat.gov.ua>
- United Nations Organisation (2014), To the question of ageing, *Report of the Second World Assembly OUN. CONF.1*, No. 97/9 final, Madrid.
- Vasilchenko, V. and Grinenko, A. (2005), *Management of the labor potential*, Tutorial book, Kyiv: Routledge.
- World Bank (2015), *Global Economic Prospects: The Economic Implications of Remittances and Migration*, Washington D.C., retrieved from <http://www.worldbank.org>