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# The system dynamic model of the labor migrant policy in economic growth affected by COVID-19

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**ABSTRACT**

At the end of 2019, the new virus called coronavirus disease (Covid-19) spread widely from China all over the world. In March 2020 the World Health Organization declared a new virus outbreak as "a global pandemic", and recommended social distancing and quarantine. Most countries in Europe have been quarantined. The social aspect of this issue is complicated by the fact that Europe nowadays hosts 82 million international migrants. If migrant workers leave the host country, it reduces the Covid-19 spread. Nevertheless, if migrant workers do not return, it will worsen the situation with the economic crisis. The subject of the study is the instrumental and mathematical aspects of impact simulation of labor migrants' policy on the economic growth of the host country affected by COVID-19 pandemic. The aim of the work is to develop the system dynamics model for assessing labor migrants' policy impact on the economic growth of the host country during COVID-19 pandemic. It examined through hypotheses of different scenarios of labor migrants policy impact on the host country economic growth in Covid-19 pandemic. The proposed model combines epidemiological and the economic growth models and relies upon real statistical data. The analysis was carried out in four European countries. The results of the study enabled to state that without migrant workers the gross domestic product may fall to 43% in Italy, 45% in Netherlands, 37% in Spain and 200% in Switzerland in 2020.

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## INTRODUCTION

Labor migration has become integral part of global labor relations. In 2019, the number of international migrants worldwide reached nearly 272 million; three of four migrants are of working age that is between 20 and 64 years (United Nations, 2019). Migrant workers have joined and blended into the labor market of the developed countries. Their rights are governed by the ICMWC, (2005). According to the Convention, a migrant worker is defined as a person who is engaged in a remunerated activity in a state of which he or she is not a national. Migrants contribute to the economic growth of both origin and destination countries. The majority of migrants send money home as remittances. According to the World Bank (2020) research, devoted to migration and development, remittances to developing countries reached a record $554 billion in 2019, an increase of 4.7 percent over the previous record in 2018. The remittances flow is not only a source of foreign currency for developing countries, but also a stable source of income for millions of families. The immigration policy of the developed country aims at meeting labor market demands. In 2019 sixty eight per cent of 111 countries identified migrant workers as sustainable economic growth tool (United Nations, 2019). Migrants often are engaged in jobs that the local population does not want to do. It leads to economic activity increase and the creation of more jobs. In addition, migrant population of working age exceeds the number of native working residents. It means that migrants make a significant contribution to the host countries' economies, including taxes and social benefits apart from their individual benefits. At the beginning of 2019, the majority of host countries had policies to raise or maintain current immigration levels through regular channels. But the unprecedented situation of the end of 2019 and the beginning of 2020 made significant changes to moving globally and commuting. The reason for the closure of state borders was the emergence and rapid spread of a new virus Covid-19. Due to quarantine in almost all developed host countries labor migration that has been established over the years may change significantly. By the beginning of the pandemic, migrants accounted for at least 10 per cent of the population in 10 of the 15 countries with the highest number of Covid-19 cases (Migration Data Portal, 2020). World Bank predicts that remittances would decline sharply by about 20 percent in 2020 due to the Covid-19 pandemic and further economic crisis. This fall could become the sharpest decline in the recent history (World Bank, 2020). New conditions call for new methods never used before, such as, modeling new economic development scenarios taking into account the spread of viruses. The practical significance of the study lies in the development of a general algorithm for simulation incorporating methods of system dynamics that can be used for assessing impact of labor migrant policy on the economic growth of the host country affected by Covid-19 pandemic.

*Literature review*

Taking into account the recent events, models that simulate the spread of viruses are of particular interest. The first attempts to study the mechanisms of disease spread were made in 17th century. Since then, the tools for predicting the future course of an outbreak have improved significantly. Further development of epidemic model can be associated with attempts to create simulation models. There are two types of simulation models, one of them is system dynamics, and the other one is agent-based model. Despite the theoretical foundation, simulation models were rarely used in practice, due to the lack of ability to conduct computer simulations (Law and Kelton, 1991). Since the 1990s, when computing tools became more powerful, simulation models have been used to solve many problems (Jeruchim *et al.,* 2000). Tomaskova *et al.* (2016) proposed the prediction of the spread of Alzheimer's disease in the EU population until year 2080 using a computer simulation. Links *et al.* (2018) developed system dynamics model of community functioning and resilience after a disaster in US countries. For China the system dynamics model was used to simulate experiments made for testing the new fertility policy (Wu *et. al.,* 2017). In order to study migration processes system dynamics model of the refugee and humanitarian crisis in Europe and the North Africa was explored (Taylor and Masys, 2018). To predict how much the Covid-19 epidemic could spread, researchers are studying different scenarios using simulation models too. One of the first simulation models (Yousuf *et al.,* 2019) based on the knowledge gained about the Covid-19 speed appeared in February 2020. Fox *et al.* (2020) is published an

epidemic simplified model for population of 4,000 people, where almost everyone is susceptible. Simulation shows that without any vaccinations, masks or quarantines each person infected with the virus would spread it to 2.3 others. The conclusion of the model is that real quarantines aren't perfect, because they are established after the onset of the epidemic. Harry Stevens simulated 4 scenarios for population of 200 people where one is ill (Stevens, 2020). Two of four scenarios are radical. In first case it is free-for-all, people can move freely without masks and social distance. In the second case for attempted quarantine the unfeasibility of complete isolation of sick people from healthy ones is proven. There are other two intermediate scenarios. Scenario "moderate distancing" assumes that a quarter of population move while the other three quarters keep social distance, for scenario "extensive distancing" the author simulated more social distancing, when one of every eight people moves around. In the example of a simulation model it was proved that moderate social distancing outperforms the attempted quarantine, and extensive social distancing works best of all. An interconnected set of simulation models is proposed by Ansys (2020), a global public company specializing on engineering simulation software for product design, testing and operation. Ansys (2020) created simulation model illustrating that cloth masks have the potential to limit the spread of sneeze and cough droplets and can reduce the risk of contaminating others by up to 6 times. Other model proves that social distancing of two meters decreases the risk to catch Covid-19 significantly because gravity pulls the carrier droplets to the ground. Also interesting is the model for mobile Covid-19 sample collection booths moved to different regions and facilitate mass sample collection. Agent-based modeling was used to analyze the Covid-19 trend (Bai *et al.,* 2020). In order to simulate the epidemic trend, a population of 10,000 people was set up, and one of them was randomly infected. The result of modeling was that through close contact approximately 10.4 % patients from 8.7% to 13.0%) were infected, the incubation time was 6.6 days (from 5.9 to 7.5 days, the cure time after the treatment was 9.8 days (from 8.8 to 10.8 days). Simulation models have shown how vulnerable people are to the virus. Next, it is necessary to study the measures taken by governments to protect the citizens of their country. Everyone who is in a certain territory is at risk of being exposed to Covid-19. Each government faces a quarantine decision. In the context of globalization, human mobility is important. To better understand how Covid-19 pandemic affects it, the International Organization for Migration (2020) has worked out a map. This map shows that in many countries during Covid-19 pandemic borders were closed. There are many migrant workers with a limited duration of a work visa. It means that leaving the country they will no longer be able to return there to work in the nearest future. This triggers quite a logical question of what is more dangerous in the conditions of a pandemic and further economic crisis: to leave migrant workers in the host country or lose their cheap labor. It is proved that the most important source of economic growth is labor productivity as the ratio of the value of output to labor input (Aghion and Howitt, 2008). Urgent is the need to attract migrant workers to developed countries due to their industrialization that created demographic transition in which birth rates decline and the average age of the population increases. Another scientific work by Błazejowski, (2019) proposes the analysis of 30 determinants of economic growth for 168 economies. As a tools a normal linear regression was used. Determinants "stock of immigrants" were listed in the top five models according to their posterior probabilities. For the host country, the advantage of migrant workers leaving is that it reduces the number of people and the requirement for social distance is easier to comply with. The disadvantage is that economic recovery will require the attraction of labor (Koziuk *et al.,* 2020). Without migrant workers it would be impossible to satisfy labor market demands quickly and efficiently. On the other hand, in conditions of unemployment, government measures would be aimed at supporting citizens and will not include migrant workers (Kozlovskyi *et al.,* 2017). For the countries of origin the advantage of migrant workers arriving is that they would not be left without a livelihood if their employers are infected, because it leads to the loss of income and work permit, tied to the employer. Migrant workers belong to a vulnerable category. It means that without a work permit, income and housing they cannot rely on the social protection of the host country. The disadvantage is obvious, for many households remittances are the only source of income, losing them they would also be on the verge of poverty and

survival (Open Knowledge Repository, 2020). It raises the debatable issue that requires a careful study of whether migrant workers should leave host country or stay in it until Covid-19 pandemic ends. Hence the goal of writing an article is to propose a simulation model based on the system dynamics for assessing impact of labor migrants' policy on the host country economic growth in Covid-19 pandemic. The object of the research is the economic growth during Covid-19 pandemic. This study was carried out in Vasyl' Stus Donetsk National University, University of State Fiscal Service of Ukraine, Chernihiv National University of Technology, Vinnytsia National Technical University, Ukraine in 2020.

## MATERIALS AND METHODS

The analysis of literary sources confirmed that models of system dynamics have proved to work well to predict population changes. Literal review enables to say that this method could be used for understanding the behavior of complex social groups. The main factors of the study are migrant workers, Covid-19 confirmed cases, economic growth. Before starting a simulation model, it is necessary to introduce hypotheses that will be tested. As hypothesis, they was taken the statement made by experts that needs to be verified by simulation (Kozlovskyi *et al.,* 2018).

*Hypothesis 1*

Migrant workers should leave the host country, because they are more vulnerable to employment loss and wages during an economic crisis in a host country.

*Hypothesis 2*

Migrant workers should stay in the host country during a Covid-19 pandemic period, because economic crisis deepens further without their labor, making economic growth impossible.

To test these hypotheses let`s build epidemiological model and economic growth model based on the system dynamics methodology. Hypotheses need to be described with all its constituent components and their interactions. It is named a casual loop diagram (Sterman, 2000). With the help of a casual loop diagram it becomes possible to ascertain the impact of labor migrants' attraction policy on the economic growth of the host country over a certain time period. Most common epidemiological model is a SIR model. SIR is an abbreviation of three components such as:

*S (t)* – is the number of individuals not yet infected with the disease at time *t* (1)

*I (t)* – is the number of individuals who spread the disease at time *t* (2)

*R(t)* – is the number of individuals who have been infected and cannot transmit the infectionto others at time *t* (3)

Important characteristics are the rate of infection and the rate of recovery. Depending on the data available to the researcher (Kaletnik *et al.,* 2019), there are various SIR model modifications (Brauer *et al.,* 2019). According to epidemiological models, the more people get sick, the more people recover. And the more people recovered and gained immunity, the fewer people became ill. According to economic growth model, the more people have recovered and are able to get to work, acting as a workforce, the more economic growth is presented. Economic growth contributes to higher living standards. It means that people can afford not to work for some time, being in quarantine. The longer the social distance regime, the fewer people are infected. In

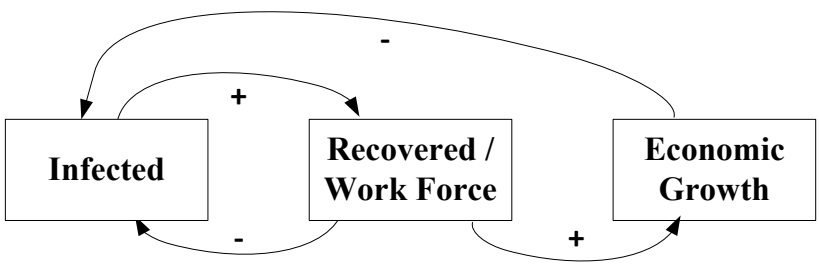



Fig. 1: Causal loop diagram of impact of labor migrants policy on the host country economic growth in Covid-19 pandemic

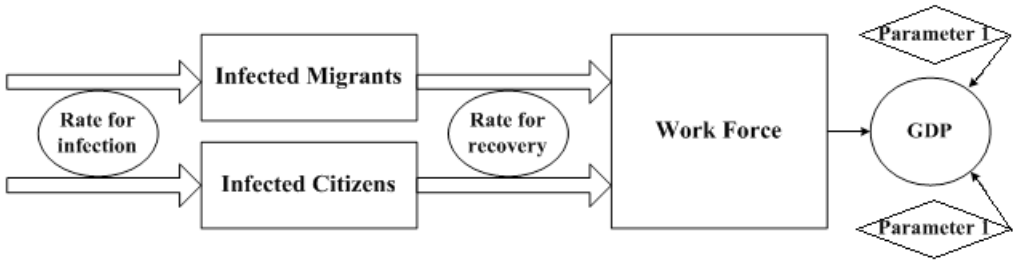



Fig. 2: Structure of epidemiological and economic growth models

To test hypothesis 1, the stock "Infected Migrants" should be equal to zero.
To test hypothesis 2, the stock "Infected Migrants" should be left unchanged.

terms of system dynamics, the relationship between components "the more, the more" is described in the form of an arc with a sign "+", and the relationship "the less, the more" is the same but with a sign "-". The causal loop diagram looks as Fig. 1.

System dynamics model structure should include stock that accumulates or depletes over time and flow that is the rate of change in a stock. In the epidemiological model it is proposed to include two stocks; the one is for migrant workers and the other is for citizens. The flow that changes the rate of infection and the rate of recovery is the same for both migrant workers and citizens. It should be noted that the statement that migrant workers unlike citizens are not socially protected and it may affect their recovery is balanced by the fact that the virus hits worse ageing people who normally refer to the native population. The economic growth rate is calculated from data on gross domestic product (GDP) estimated by statistical agencies. For GDP total workforce is one of the factors affecting the growth (Fioramonti, 2013). For estimating the relationships between GDP and workforce it is reasonable to use regression analysis (Darlington and Hayes, 2013). For economic growth model it is proposed to use GDP as the outcome variable, and workforce as the predictor. In terms of system dynamics stocks that describe both migrant workers and citizens are total workforce. GDP is proposed to describe by a function, where parameters of simple linear regression are introduced as constants. Dynamics stocks are represented by rectangles, functions are arrows with circles, and constants are rhombs. The structure of system dynamics model can be represented in this way (Fig. 2).

## RESULTS AND DISCUSSION

*Model implementation in a software product*

To implement the proposed study methodology to hypothesis testing whether migrant workers should leave or stay the host country during Covid-19 pandemic, it is necessary to build a system dynamics model in a software product. Among the variety of software products for the system dynamics method, it is better to choose the one that has a free download possibility for educational and scientific purposes and at the same time uses simulation tools that cover all needs for building simulations. Powersim Studio 10 Products has these characteristics. Stocks "Infected", "Recovered", and "Infected Migrants", "Recovered Migrants" output the size of work force at a specific time. Stocks "Infected Migrants", "Recovered Migrants" are defined as the multiplication of the migrant workers share and total work force of the host country, and stocks "Infected", "Recovered" are defined as total work force reduced by the number of migrant workers. In the Powersim Studio 10 (Powersim software, 2020) model these tools are determined automatically by dragging elements to each other. Stocks cannot exist without flows that change the meaning of infected and recovered people in stocks. Rates for infection and recovery are always a probability number. In the Powersim Studio 10 model function "Random" is used to set a random value for uniform distribution in a given range. There is some time between getting infected and the onset of the Covid-19 disease. Because the incubation time for Covid-19 is about some days, that is not a long period especially in quarantine conditions, this figure can be neglected. In order to take into account that the

number of people infected by Covid-19 in different countries is uneven, it is proposed to introduce a correction factor to the rate of infection. Further, it is necessary to determine the GDP linear regression parameters. Powersim Studio 10 does not have a function that enables to determine the parameters from the collected data. So it is necessary to carry out preliminary calculations and enter the results as constants. Assessment model of impact of labor migrants' policy on the host country economic growth in Covid-19 pandemic is implemented in a Powersim Studio 10 can be represented in this way (Fig. 3).

*Data*

One of the most important issues in building a high-quality simulation model is the availability of reliable incoming information. To implement the model of impact of labor migrants' policy on the host country economic growth in Covid-19 pandemic on real data it is proposed to use reliable data that are publicly available as source data. These data include information from Open Data website World Bank. It offers free access to indicators about countries around the globe. Another source of information is Migration Data Portal (2020). It offers statistics referring to international migrant stocks. Using these data calculate the GDP linear regression parameters. As an example, take European developed countries. Let us choose countries with the largest and smallest number of Covid-19 confirmed cases per 1 million population on June 2020. These are Spain with 5120 confirmed cases and the Netherlands with 2710 confirmed cases per 100,000 population (Worldometer, 2020). Let choose countries with the largest and the smallest number of migrants. These are Switzerland, where migrants make up 30% of population, and Italy with 10.4% migrants (Migration Data Portal, 2020). Covid-19 data for chosen countries are presented in Table 1.

Suffice it to note that the presented in Table 1. Thus, Italy, Netherlands, Spain and Switzerland

Table 1: Covid-19 data

| Country | Total cases, 01.06.2020 | Total deaths, 01.06.2020 | Covid-19 death rate, 01.06.2020 | Total cases per million, 01.06.2020 |
|---|---|---|---|---|
| Italy | 233019 | 33415 | 113,151 | 3853,985 |
| Netherlands | 46442 | 5956 | 109,361 | 2710,379 |
| Spain | 239429 | 27127 | 99,403 | 5120,952 |
| Switzerland | 30779 | 1656 | 99,739 | 3556,367 |

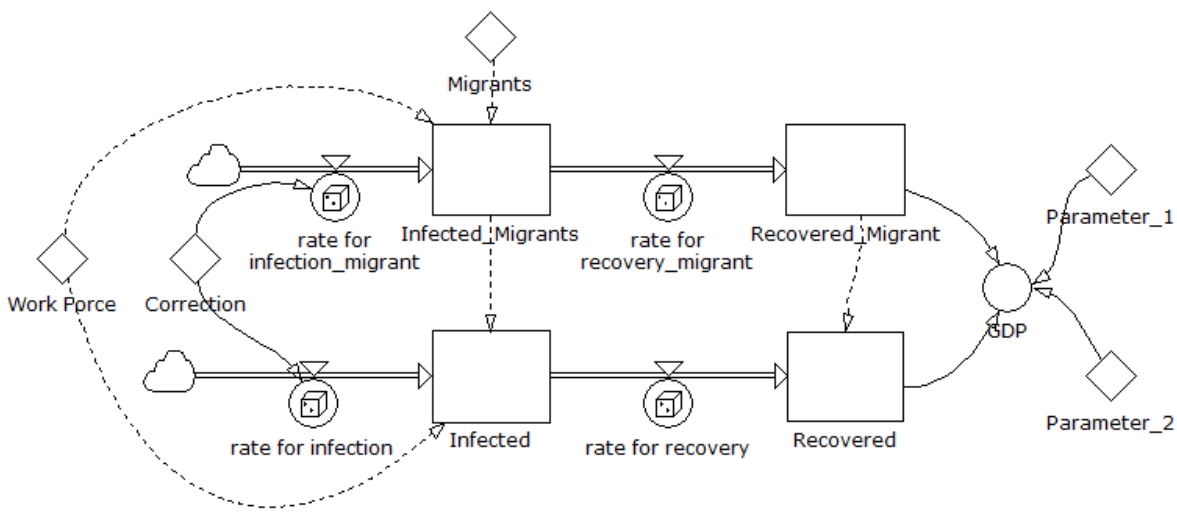



Fig. 3: Epidemiological and economic growth models in a Powersim Studio 10

presently do not actively use economic and political mechanisms for restricting migrant labour influx and flow. Only since June 2020 some European countries such as Poland, Finland and others have raised the issue of restraining the outflow of migrants back home. For this purpose, governments started to create mechanisms of regulating migration flow (insurance provision, additional payments etc). GDP information in current US$ is taken from (World Bank, 2020), information on labor force is available here at this link (World Bank, 2020). Data set is taken from 1990. Modeling was carried out in MS Excel. The information is presented in the regression line demonstrates the strong relationship between GDP and labor force for analyzed European countries (Fig. 4).

For Switzerland and Spain the strength of a linear relationship between GDP and labor force is extremely high and equal 96%, for Netherlands correlation coefficient is 90%, for Italy it is 78% that is indicates relationship between two variables. The regression model parameters obtained automatically in MS Excel, and other constants that are used as incoming data for system dynamics model are presented in the Table 2.

To determine the rate for infection Covid-19, let use the results by Bai *et al.* (2020) estimating that from 8.7% to 13.0% persons were infected through close contact. Since the official statistics on Covid-19 mortality are highly dependent on reporting standards in different countries, it is proposed to take the range between 94% and 98% as a rate for recovery.

*Result of modeling*

To test Hypothesis 1 that is to explore the consequences of migrants leaving the host country constant "Migrants" is equal to zero in the

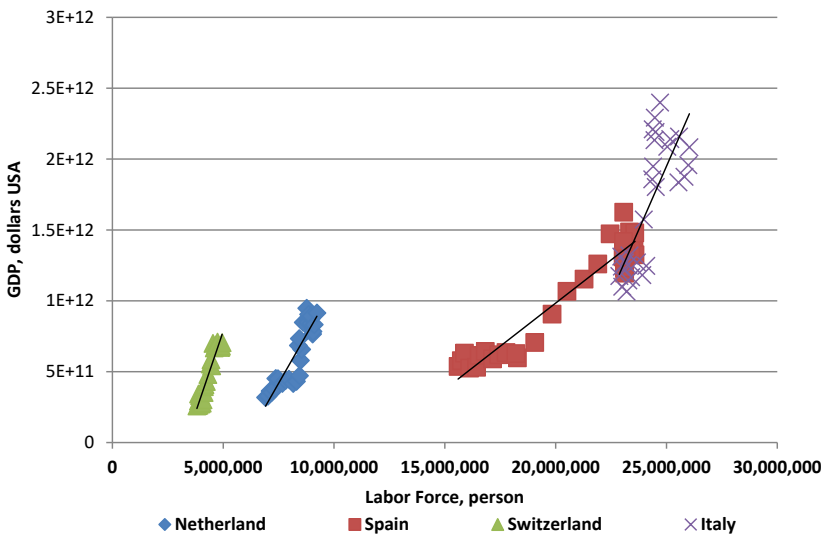


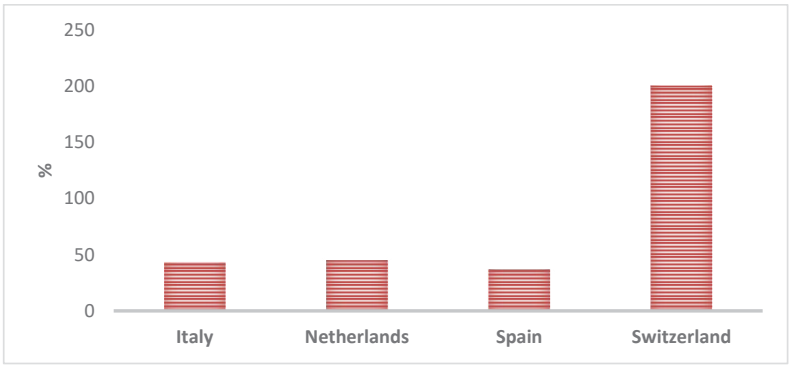

Fig. 4: Linear regression of annual GDP and labor force in European countries

Table 2: Constants of the epidemiological and economic growth models in a Powersim Studio 10

| Country | Share of working age migrants in work force, %, 2019 | Work Force, person, 2019 | Covid-19 spread factor | Regression coefficient (intercept) | Regression coefficient (slope) |
|---|---|---|---|---|---|
| Name of constant in model | Migrants | Work Force | Correction | Parameter 1 | Parameter 2 |
| Italy | 8,9% | 25964342 | 1 | $-7{,}003*10^{12}$ | 358088 |
| Netherlands | 10,5% | 9247803 | 0,8 | $-1{,}6*10^{12}$ | 273715 |
| Spain | 10,6% | 22943908 | 1,2 | $-1{,}4*10^{12}$ | 121669 |
| Switzerland | 23,5% | 4981104 | 1 | $-1{,}5*10^{12}$ | 458609 |

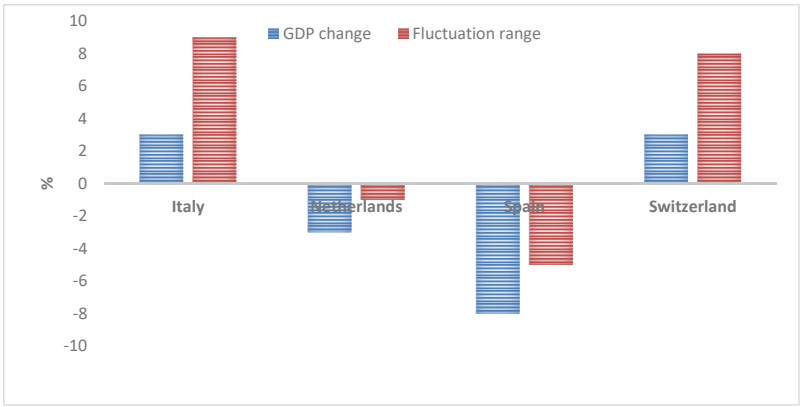
epidemiological and economic growth models in a Powersim Studio 10. On the other hand, the population affected by the Covid-19 decreased by the number of migrant workers. Under such circumstances, it is easier to maintain a social distancing. On the negative side, the contribution of labor to GDP also decreased in proportion to the contribution of migrant workers. The results of testing Hypothesis 1 are shown in the Fig. 5.

Switzerland may be most affected by the lack of migrant workers (Table 1). This is due to the fact that almost a quarter of workers are migrants. While the GDP falls in European countries with the migrant workers number about 10% would be from 37% to 45%, in Switzerland it is calculated not in percentage, but in times and can reach 3 times. In Italy losing migrants as a labour force, the losses in GDP can at the peak bring 4 times more losses of GDP in relation to the average growth value; in average in Italy migrants produce 10% GDP (InfoMigrants, 2017). This process can be explained by the fact that with the reduction of the migrant labour force Italy will drastically lack own labour forces. And at the peak the losses in GDP 43% can reasonably follow. Such situation has a high




| Country | *Hypothesis 1* |
|---|---|
| Italy | ≈ 43 % |
| Netherlands | ≈ 45 % |
| Spain | ≈ 37 % |
| Switzerland | ≈ 200% |

Fig. 5: GDP decline in the absence of migrant workers




| Country | *Hypothesis 2* |
|---|---|
| Italy | [3%,9%] |
| Netherlands | [-3%,-1%] |
| Spain | [-8%,-5%] |
| Switzerland | [3%,8%] |

Fig. 6: GDP change in the presence of migrant workers

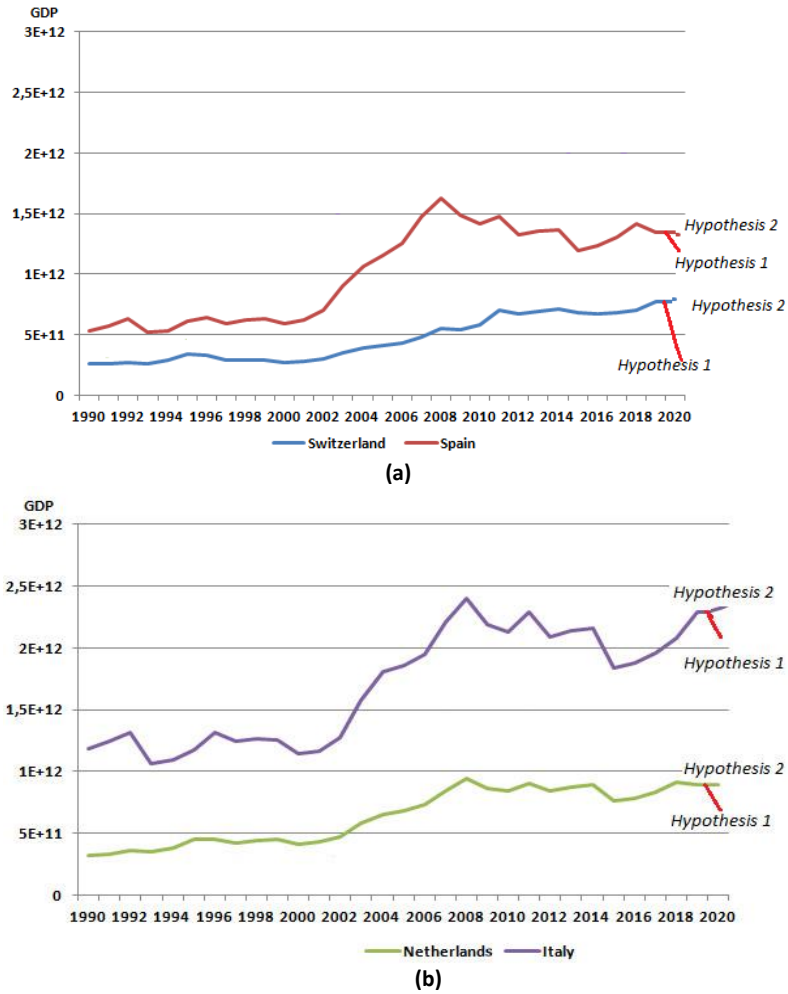



Fig. 7: Simulation results of the epidemiological and economic growth models: (a) comparison of Switzerland and Spain; (b) comparison of Netherlands and Italy

probability because Italy does not possess its own labour resources to replace the missing ones. In its turn such a situation will be followed by a chain of economic processes, which can shatter the economy of the country on a larger scale. To test Hypothesis 2 for each analyzed country constant "Migrants" is determined (Table 1). Results of modeling of the epidemiological and economic growth models in a Powersim Studio 10 are shown in the Fig. 6.

As it can be seen from the Fig. 6, GDP change in the presence of migrant workers may be from 3% to 9% in Italy and from 3% to 8% in Switzerland. It means that Italy and Switzerland do not even feel the economic crisis, in condition that the work force decreases only by the number of people affected by the Covid-19. 1-3% GDP decrease is expected in Netherlands and 5-8% in Spain. These countries may experience a slight decrease in GDP. It is more connected with previous trends rather than with a Covid-19 pandemic. The dynamic simulation results of the epidemiological and economic growth models are not exact numbers, but trends are to be expected (Fig. 7).

The simulation results of impact of labor migrants' policy on the economic growth of the host country in Covid-19 pandemic consider a single aspect. There are other equally important factors that can affect the decline in GDP. Among them such factors can be identified as unemployment and fall in demand. In quarantine business does not work that hinders

economic growth. The number of newly unemployed people increases exponentially. Governmental measures may not be enough to stop this tendency (Jones *et al.,* 2020). The economic damage caused by the Covid-19 pandemic is driven by a fall in demand. Consumers are not able to purchase the goods and services. In the global economy it means falling demand for oil and new cars, reduction in travelling and tourism, Internet-retail sales (Duffin, 2020). The results from McKinsey Global Survey on the economy point that at the company level, respondents most often cite weak consumer demand as a threat to their growth (McKinsey and Company, 2020). The factors listed above are not taken into account in the epidemiological and economic growth models. This does not diminish its value, because the goal of simulation is not to calculate exact numbers, but to show the scale of changes and general trends. The results of modeling in a Powersim Studio 10 showed that the outflow of migrant workers would only worsen the economic crisis for the host country. The impact of the Covid-19 pandemic is individual for each country and among all factors the ability to satisfy labor market demands would be strongly required.

## CONCLUSION

The proposed approach to simulation economic development scenarios and migrant's policy taking into account the Covid-19 pandemic was implemented in a software product Powersim Studio 10. The preliminary steps to the model practical implementation were the creation of the causal loop diagram of migrant labor policy impact on the host country economic growth in Covid-19 pandemic and structure of epidemiological and economic growth models. The effective implementation of the system dynamics model involved the determination of its constants, which included a share of working age migrants in labour force and Covid-19 spread factor. For estimating the relationships between GDP that is the source of information about economic growth rate and workforce, the regression coefficient was also defined as constants. A specific of the model of impact of labor migrants' policy on the host country economic growth in Covid-19 pandemic is that the data was taken from official websites, which are updated in real time. It means that both scientists and practitioners interested in this issue can not only build a model according to the proposed algorithm, but also use the most relevant information. Based on the proposed and implemented the epidemiological and economic growth models, such results of the labor migrant policy impact on the economic growth of the host country affected by Covid-19 pandemic were obtained. The analysis was carried out in four European countries. In Spain, where the largest number of confirmed Covid-19 cases, the GDP decline in the absence of migrant workers would be the lowest, but it also would not show growth in their presence. In Netherlands, with the smallest number of confirmed Covid-19 cases, the GDP could decline by 45% and approximately 2% if migrant workers would leave country and stay in it respectively. The number of migrants is the same in these countries. Italy is less dependent on migrants than other European countries. Its GDP may fall by 43% if migrant workers are not engaged in labor activity, and increase by 3-9% if the policy of attracting migrants remains unchanged. Switzerland is extremely dependent on migrant workers. While their absence can have a catastrophic effect on GDP, their presence leads to an increase in GDP. In Italy and Switzerland Covid-19 confirmed cases are slightly different. From here it the following generalized conclusions can be drawn as: 1) Migrant workers department policies have a greater impact on reducing GDP than Covid-19 mortality. 2) If the country's economy tended to grow, it would recover quickly after Covid-19 pandemic while meeting labor market demands. 3) GDP shows a drastic decline in countries with the large number of migrant workers if they leave the host country during a Covid-19 pandemic. Given the lack of information about the new virus Covid-19 and its impact on the global economy, the obtained simulation results are one of the first attempts to make research in this direction. Conclusions about the impact of labor migrants' policy on the economic growth and can be used in future forecasting.

## AUTHOR CONTRIBUTIONS

S. Kozlovskyi worked on a literature review devoted to Covid-19 pandemic and collected statistical information about confirmed cases in Spain and the Netherlands. D. Bilenko implemented epidemiological and economic growth models in a Powersim Studio 10. M. Kuzheliev formulated hypotheses about impact of labor migrants' policy

on the host country economic growth in Covid-19 pandemic to be tested. R. Lavrov made a review of international studies on the simulation modeling topic and collected economic growth information. V. Kozlovskyi proposed diagram of the labor migrants policy impact on the host country economic growth in Covid-19 pandemic and structure of epidemiological and economic growth models. H. Mazur did a linear regression of annual GDP and labor force in European countries. A. Taranych investigated the issue to take into account other factors other than the labor force for changing GDP during the Covid-19 pandemic.

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## CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

## ABBREVIATIONS

| | |
|---|---|
| *A* | Average |
| *Correction* | *Covid-19 spread factor in country* |
| *Covid-19* | *Coronavirus Disease* |
| *EU* | *European Union* |
| *GDP* | *Gross domestic product* |
| *I (t)* | *Number of individuals who spread the disease at time t* |
| *Infected* | *The number of citizens who have Covid-19* |
| *Infected Migrants* | *The number of migrants who have Covid-19* |
| *ICMWC* | *International Convention on Migrant Workers and its Committee* |
| *Migrants* | *Share of working age migrants in work force* |
| *Parameter 1* | *Regression coefficient (intercept) of the influence of migrant workers on GDP* |
| *Parameter 2* | *Regression coefficient (slope) of the influence of migrant workers on GDP* |
| *R(t)* | *Number of individuals who have been infected and cannot transmit the infection to others at time t* |
| *Rate for infection* | *Probability to have Covid-19 among citizens* |
| *Rate for infection_ migrant* | *Probability to have Covid-19 among migrants* |
| *Rate for recovery* | *Probability to recover from Covid-19 among citizens* |
| *Rate for recovery_ migrant* | *Probability to recover from Covid-19 among migrants* |
| *Recovered* | *The number of citizens who have recovered from Covid-19* |
| *Recovered_ Migrant* | *The number of migrants who have recovered from Covid-19* |
| *S (t)* | *Number of individuals not yet infected with the disease at time t* |
| *US$* | *Dollars of USA* |
| *Work Force* | *Employed people* |

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