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**CAUSAL IMPACT OF SCIENCE AND TECHNOLOGY
PARKS ON ECONOMIC GROWTH. THE CASE OF
BELARUS.**

Master's Thesis

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Name and signature of supervisor.....

Allowed for defense on

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I have written this master's thesis independently. All viewpoints of other authors,
literary sources and data from elsewhere used for writing this paper have been
referenced.

(signature of the author)

Abstract

Science and technology parks play an important role in the modern economy and become a key factor in economic development in countries with transitive economies. The research paper demonstrates a causal impact of science and technology parks on the economic growth of the country and based on the results of the analysis suggests recommendations for countries to improve their economic indicators by creating and/or enhancing conditions of science and technology parks. The research is being done by applying the method of synthetic control on the Belarusian case using the World Bank data. The findings of this research help to understand the importance of the science and technology parks.

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Abbreviations, Constants, Definitions

GDP — gross domestic product

IT — information technologies

FDI — foreign direct investment

STP — science and technology park

HTP — High Technology Park

SEZ — special economic zone

GFFC — gross fixed capital formation

UNESCO — United Nations Educational, Scientific and Cultural Organization

UKSPA — United Kingdom Science Park Association

ICT — information communication technologies

RMSPE — root mean square prediction error

1. Introduction

A modern economy is characterized by the processes of globalization, integration, and liberalization. Therefore, such structural elements as science and technology parks start playing an important role in the development of national economies. The analysis of economic development requires the consideration of modern society functioning. Currently, the modern world economy is at a post-industrial stage of development, and its current trends increased the global competition. Within last 30 years, global corporations entered various new markets and their current profit makes up to 10% of global GDP considering the fact that all participants of international economic relations function in the condition of limited strategic resources (Osmova, 2008, The new global competition for corporate profits, 2015).

The current stage of development of the global economy is characterized as informational and can be described by an increase in the degree of openness of national economies. Information and knowledge became key values of economic development and the IT sphere attracts bigger volumes of investments. Above-mentioned factors create a perfect environment for such structural elements as science and technology parks.

Science and technology parks have different effects on the economy and the development of a country. For example, they can promote cooperation for innovation by creating specific intangible results from cooperation for the companies that are residents of a park (Vasquez-Urriago et al., 2012). The active development of science and technology parks raises the question of their impact on the economic growth and national economy.

Currently, many economists research the topic of economic growth and the factors that have an impact on it. The issue of economic growth became extremely important for countries with transitive economies. Science and technology parks (STPs) may become a key factor for economic growth and its increase. In this research paper, the causal impact of STPs is analyzed based on the example of the Republic of Belarus. In this paper, the positive impact of science and technology parks on economic growth will be demonstrated and recommendations for the creation and development of STPs will be developed.

The key analytical technique of this paper is the synthetic control method that has proved its effectiveness in comparative case studies. This method was developed by

Abadie and Gardeazabal (2003) and was well-described in the research of California's tobacco control program (Abadie et al., 2010). Detailed recommendations on how to use synthetic control for comparative case studies given in the California research are used as instructions for the method usage in this research paper.

The interesting fact about the synthetic control method is that there was no study found during the literature search regarding the application of this method to the Belarusian economy. In this research paper, the main focus is on the biggest Belarusian science and technology park — the High Technologies Park (HTP). This park demonstrates impressive results of its functioning (see Table 1).

Table 1. HTP results in 2017

HTP results	
HTP Export	\$1.025 billion
Software Development Annual Growth	121%
FDI flow	\$191M
New Working Places Created	5160

Source: HTP Announced the Results of 2017 (n.d.)

Based on this statistical data we can suppose that this structural element has an impact on economic indicators. This Master thesis focuses on the IT industry and its influence on economic development in order to find causality between STPs and economic growth.

This research paper provides a comparative study between Belarus and countries without science and technology parks in order to find and prove the impact of such parks on economic growth using the methods of analysis, comparison, and synthetic control.

The research paper suggests the following hypothesis:

STPs have a positive impact on economic growth.

The aim of the research paper is to prove that science and technology parks have a causal impact on the economic growth of the country and to develop recommendations for countries to improve their economic indicators by creating and/or enhancing conditions of STPs.

The Master thesis has the following structure: Part 2 presents the theoretical background of this research and gives a literature review. Part 3 describes the research method and used data. Part 4 describes the synthetic control comparative analysis in details and shows the results derived from the analysis and discusses the impact of science and technology parks on economic growth and suggests recommendations. Part 5 presents the conclusion of the Master thesis.

2. Theoretical aspects of science and technology parks

2.1 Terminology

There are various descriptions of science and technology parks. For example, according to International Association of Science Parks and Areas of Innovation, a science and technology park can be described as “an organization managed by specialized professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions” (IASP. Definitions, n.d.). In this research paper definitions approved by UNESCO are used.

One of the definitions accepted by UNESCO was given by the United Kingdom Science Park Association (UKSPA). According to UKSPA (UNESCO Concept and Definition, n.d.), “a science park is a business support and technology transfer initiative that:

- Encourages and supports the start-up and incubation of innovation-led, high-growth, knowledge-based businesses.
- Provides an environment where larger and international businesses can develop specific and close interactions with a particular center of knowledge creation for their mutual benefit.
- Has formal and operational links with centers of knowledge creation such as universities, higher education institutes, and research organizations”.

We can see that the Belarusian High Technology Park goes under this definition. The HTP cooperates with biggest Belarusian universities (Belarusian State University and Belarusian State University of Informatics and Radioelectronics) and has created branches of these universities at the Park's territory (HTP Opened 6 Department Branches of BSU and BSUIR, n.d.). Moreover, the Park has its own business incubator that was created with the aim to support startups (HTP Business Incubator, n.d.).

To understand the principles of HTP functioning it is important to research a legal basis. According to the Decree No 12 of the President of The Republic of Belarus (2005), the HTP was created with an aim to provide favorable conditions for enhancing the competitiveness of economic sectors of the Republic of Belarus based on new and high technologies, further improvement of the organizational, economic and social conditions

in order to develop modern technologies, increase their export, and attract domestic and foreign investments in this area (Decree No 12, 2005).

2.2 Literature Review

As a preparation for the research dozens of articles and Internet resources were analyzed. Due to the specific research topic, some of the literature sources that are used for the theoretical part of the research are in Russian and Belarusian languages.

In several sources, technology parks are considered to be a type of special economic zones. For example, in some English sources the HTP is stated as a special economic zone (Belarusian High Technologies Park, n.d.), however, in the Decree N12 of the President of The Republic of Belarus on High Technology Park it is emphasized that the Park is not special/free economic zones, even though Park's residents have some legal and tax privileges (Decree N12, 2005). Also, HTP is not in the official list of Belarusian special/free economic zones (Free economic zones, n.d.).

Considering the confusion among English literature sources several articles on special economic zones (SEZ) were studied to understand the difference between science and technology park and special economic zone.

The majority of the authors agrees that SEZs play a significant role in the modern economy. For example, Zeng (2016) describes SEZs as “an effective instrument to promote industrialization and structural transformation” and gives several examples of successful and failed implementations of SEZs. The research shows that free economic zones can have a positive impact only if they are implemented properly considering national economy functioning and business culture in a particular country (Zeng, 2016).

SEZs have an influence on the company's export operations. The analysis of SEZs in Africa and Asia performed by using econometric testing proves that such zones have a positive impact on export operation only in countries with open economies (Davies & Mazhikeyev, 2015).

There are various reasons for the successful implementation of SEZs. For example, the study of SEZs impact on regional economic development shows that the success or failure of the SEZs implementation and their impact on development depend on various factors, such as “wages and productivity in the region, trade preferences,

market outlook, governmental policy and the macroeconomic environment, the incentives offered to investors, quality of design, and program execution” (Zaldívar & Molina, 2018). Similar research was done for SEZs in Sub-Saharan Africa (Curran, 2009). The example of Sub-Saharan SEZs can be used in the research to compare situations in developing countries and transitive economies.

SEZs also can have an impact on the employment demonstrated in the research by Aggarwal and Aradhna (2007). In their paper, the examples of SEZs in Asia are given and the results of the research demonstrate that the connections between countries with different development levels boost the trade in the developing Asian countries (Aggarwal & Aradhna, 2007).

Discussing the importance of special economic zones many authors bring China as an example. Good explanation of the successful implementation of special economic zones in China is presented in the research paper by Wang (2013) where the impact of free economic zones on foreign direct investment is analyzed. The empirical study proves that such zones increase the volume of direct foreign investment (Wang, 2013).

As a preparation for science parks analysis dozens of articles and Internet resources on this topic were researched. The main aim of the literature search was to analyze the impact science and technology parks on the national economy.

Together with special economic zones science and technology parks are well-developed in China. According to Zhang and Sonobe (2011), science and technology parks (especially high-tech companies) have a positive impact on the volume of foreign direct investments (FDI). Here, should be noted that FDI flow can be the key indicator of economic growth.

However, there are arguments regarding the potential impact of science and technology parks. The question of their impact was raised in the paper about an empirical analysis of STPs effects on job growth and venture capital by Wallsten (2004). The results of the analysis published in 2004 were quite surprising as they demonstrate that policies implemented to promote cluster development by subsidizing science or research parks most likely do not have a positive effect on the economy. However, other research papers demonstrate that science and technology parks can have a positive impact on regional development and employment. For instance, the study based on the example of Hungary

(Lukovics & Dusek, 2014) shows that such parks can increase the level of employment in the country and improve indicator of gross annual income.

Science and technology parks may also affect particular industries of the national economy. The research of the potential development of technoparks for film, game and animation industry based on the case of Indonesia by Wikayant (2017) provides the analysis of the potential effects of science and technology parks on the specific industries.

According to the research by Oxford University, science parks increase the level of economic activity and the productivity of companies and develop an environment with a strong focus on collaboration and innovation (University of Oxford Science Parks, n.d.).

STPs create different values for their residents. For example, according to the research by Albahari et al. (2018), there are two business support components: configuration-oriented (the static design of the business support) and process-oriented (management's hands-on support) components. For value creation, the management should have a comprehensive view during the designing and implementation of the park's offer (Albahari et al., 2018).

Silicon Valley in the USA is considered to be the first science and technology park. In many cases, a University plays a significant role in the park's formation and functioning. Science and technology parks together with the University creates various impacts of economic development. According to Linket et al. (2018), STPs can have impacts in 3 ways: direct, indirect, and induced impacts. "Direct impacts represent the dollar value of the activities of park tenants such as wages, operating expenditures, and capital expenditures. Indirect impacts are multiple of direct impacts; they represent the dollar value of activities in firms that interact with park firms (e.g., suppliers). Finally, induced impacts represent the value of consumption expenditures of direct employees in the park and indirect employees in other firms on durable and non-durable items" (Linket et al., 2018).

2.3 Overview of the Belarusian economy

To analyze science and technology parks in Belarus it is important to understand the vital principles of the Belarusian economy functioning. The Republic of Belarus is an

export-oriented country with a developed industry, service sector, and agriculture. The Belarusian economy had the following key sectors (Economy of Belarus, n.d.):

- industry;
- agriculture;
- construction;
- trade;
- transport;
- information and communication technologies.

Growing global IT demand creates opportunities for the development of export-oriented information technologies in Belarus. In the past few years, the IT sector has received serious government support and has become one of the priority areas for the development of the national economy.

Among the countries of the Customs Union, only Belarus has a positive balance of computer services which is constantly growing. For example, in 2009 the balance amounted to \$ 121.5M, in 2010 - \$ 172.1M, in 2011 - \$ 227.6M, in 2012 - \$ 352.1M, in 2013 - \$ 480M (Belarusian National Statistic Committee, n.d.). The largest supplier of computer services in Belarus is the High Technology Park (HTP Announced Results 2016, n.d.).

The share of exports of computer services in the total export of services of the Republic of Belarus increased in the period of 2011–2017 by 3.1 times and amounted to 15.4% in 2017 (in 2016 – 14%) (Economy of Belarus, n.d.).

Also, the country has good global positions in terms of active development of information and communication technologies. According to the estimates of the International Telecommunication Union, the Republic of Belarus ranked 32nd in the ranking of 176 countries in the Information and Communication Technologies Development Index (Economy of Belarus, n.d.).

According to the UN e-government report “Review 2018: E-government as support for sustainable development”, Belarus ranked 38th in the e-government readiness index rating among 193 countries in the world (Economy of Belarus, n.d.).

2.4 Belarusian IT sector and High Technology Park

Today information technologies are one of the main resources for the development of the global economy, therefore the information technology sector is becoming the center of the economic restructuring for the countries with transitive and developing economies.

Growing global demand creates opportunities for the development of export-oriented information technologies sphere in the Republic of Belarus. In the past few years, the information technology sector of the Republic of Belarus has received serious governmental support and has become one of the priorities for the development of the country's economy.

Currently, Belarus demonstrates the stable growth of the information technology sector. IT sector has become the second largest contributor to a positive balance of services exported (The IT Industry in Belarus: 2017 and Beyond, n.d.).

The growth of this sphere has a positive impact on the indicators of the economic development of the national economy and increases the FDI flow.

In the Republic of Belarus, information and communication technologies play an important role. More than 90% of Belarusian IT industry is external and export-oriented, however, the state still has a strong influence on the industry in the form of local laws and governing the business environment (The IT Industry in Belarus: 2017 and Beyond, n.d.).

Currently, the foundations of the information society were formed in the country, and a legal basis has been created for the informatization process of society (SCST of the Republic of Belarus, 2017).

Modern Belarus is characterized as an IT country. Decree No 8 "About development of the digital economy" signed by the President of the country in December 2017 created favorable conditions for IT development (Decree No 8, 2017). Belarus has become the first country in the world that fully legalized financial operations with cryptocurrency and smart contracts (Decree No 8, 2017). Also, in January 2019 the first official cryptocurrency stock exchange was created in the country (Belarusian cryptocurrency stock exchange, n.d.). In 2018 Belarus was ranked 13th country in the world in the list of the countries with the most favorable conditions for blockchain development (Blockchain and cryptocurrency regulation index, 2019).

As for the growth of the information technology sector itself, the situation in the country is primarily associated with both global trends and the success of individual IT

companies (for example, EPAM Systems became the first Belarusian company listed on the New York Stock Exchange) (IPO EPAM Systems, 2012).

Even though the dramatic changes in IT industry happened in the period of 2005-2019, the formation of the information society started in 2001.

In December 2001 the science and technology association “Infopark” was created in Belarus in accordance with the Decree of the President No. 234 “On State Support for the Development and Export of Information Technologies” (2001). In accordance with this Decree, the draft state program for the development and export of information technology was developed, providing a set of measures for the training and retraining of specialists in the field of information technology (Decree No 234, 2001). In my opinion, this Decree and subsequent Infopark creation formed the basis for the development of IT sector in the country.

Further on, in 2002, the special state program “Digital Belarus” was developed with the aims to form a single information space as one of the stages of transition to an information society and to ensure the creation of conditions for improving the efficiency of the economy, state and local government (State Program “Digital Belarus”, 2002).

The Association has been playing a leading role in the developing sector of the Belarusian digital economy. Its main goal is the development of a business cluster of software engineering and its diversification (Decree No 234, 2001). The Infopark contributes to the training of specialized personnel, as well as the establishment of international relations. Infopark opening started the process of IT development in the country and created the anticipation about the further IT sphere growth that led to the opening of the High Technology Park. On September 22, 2005, the President of the Republic of Belarus signed Decree No. 12 (2005) "On the High Technology Park", and in June 2006, the first residents were accepted.

The High Technology Park is known as the European Silicon Valley (Weinberg, B., 2019). First members of the park (EPAM Systems, System Technologies, ScienceSoft, and Sakrament IT) play a key role in European software development and IT industry (Weinberg, B., 2019). The High Technology Park is the main supplier of computer services in Belarus, the residents of HTP export about 91% of produced software (HTP statistics, n.d.).

The Park has been actively developing and currently 505 companies involved in software products development and providing IT services are residents of the HTP (HTP residents, n.d.). It should be noted that currently, more than 1 billion people in 193 countries of the world use mobile applications developed by the residents of the HTP (HTP statistics, n.d.).

The main customers importing software developed by the HTP are in the United States of America, the United Kingdom, Germany, Russia, and Ireland. In 2016, the residents of the Park entered the markets of the Philippines, Vietnam, Turkmenistan, and Mexico (HTP Announced Results 2016, n.d.).

Resident companies have significant state support: they are exempted from most taxes, including value-added tax and income tax. In addition, employees have a 30% reduction in personal income tax compared with other sectors of the economy (The IT Industry in Belarus: 2017 and Beyond, n.d.).

The HTP plays an important role in the development of international cooperation and contributes to the global exchange of technology and education. For example, on January 12, 2012, the Belarusian-Indian training center was created on the basis of the HTP. The main activity of the center is the training of highly qualified personnel in the field of information technology (India-Belarus Digital Learning Centre in ICT, n.d.).

Due to the Park, Belarus managed to create a well-developed export-oriented software development industry and became a significant player in the IT market in Europe (The IT Industry in Belarus: 2017 and Beyond, n.d.), and since the Park creation there was 30 times growth in the computer service exports (The IT Industry in Belarus: 2017 and Beyond, n.d.).

The HTP is famous for its residents. For example, such successful companies as EPAM Systems, Wargaming, Viber are residents of the Park and have their offices inside Park infrastructure. Products developed by HTP residents have a demand all over the world. For example, World of Tanks by Wargaming is one of the five most profitable MMO games in the world with over 140M users registered. Moreover, HTP residents attract the attention of big corporations, for instance, MSQRD was bought by Facebook in 2016. (The IT Industry in Belarus: 2017 and Beyond, n.d.)

Considering the above-mentioned, we can suppose that the HTP has an impact on the Belarusian economy.

3. Research Methods

3.1 Synthetic control method

For the research, the method of synthetic control was chosen. This method represents a data-driven technique to study the effects of events or interventions that take place at the country level. Basically, a synthetic control method is “a weighted average of the available control units, the synthetic control method makes explicit: (1) the relative contribution of each control unit to the counterfactual of interest; and (2) the similarities (or lack thereof) between the unit affected by the event or intervention of interest and the synthetic control, in terms of pre-intervention outcomes and other predictors of post-intervention outcomes. Because the weights can be restricted to be positive and sum to one, the synthetic control method provides a safeguard against extrapolation” (Abadie et al., 2010).

The synthetic control method is used for comparing such aggregate units as countries, cities or regions, as it is not possible to use a single comparison for them. The synthetic control implies that a combination of comparison units can reproduce the analyzed characteristics better than a single unit (Abadie et. al., 2012). In the case of Belarus to estimate the effect of science and technology parks it is necessary to use a combination of the countries with similar economic and/or political situation. The synthetic control suggests that the comparison unit is chosen as a weighted average of all possible comparisons with similar characteristics. The main advantage of the synthetic control is the usage of the weighted average as it prevents the type of model-dependent extrapolation usually used in the regression analysis (Abadie et. al., 2012).

Synthetic control methods are well-described in the study on the effect of California's tobacco control program (Abadie et al., 2010). The study explains the synthetic control method using the example of anti-tobacco law in California and gives detailed recommendations on how to use the synthetic control for comparative case studies. The results of the study show the difference in tobacco consumption before and after the anti-tobacco law implementation (Abadie et al., 2010).

Generally, synthetic control can be expressed by the following model that generates generate mean-unbiased proxy (P) (see Formula 1):

$$P_t^N = \sum_{j=2}^{J+1} w_j Y_{jt} \text{ where } w \geq 0 \text{ and } \sum_{j=2}^{J+1} w_j = 1$$

Formula 1. Synthetic control

Source: Chernozhukov et al., 2017

In this model, Y represents a treatment unit at the time period t with weights w .

Synthetic control can be performed in R, STATA, and MATLAB. In this paper, STATA software is used for the analysis.

In STATA synthetic control is conducted in 3 steps (see Figure 1):



Figure 1. Synthetic control steps

Source: Author's evaluation based on STATA synth package

Results of the synthetic control are represented in several sections (see Figure 2):

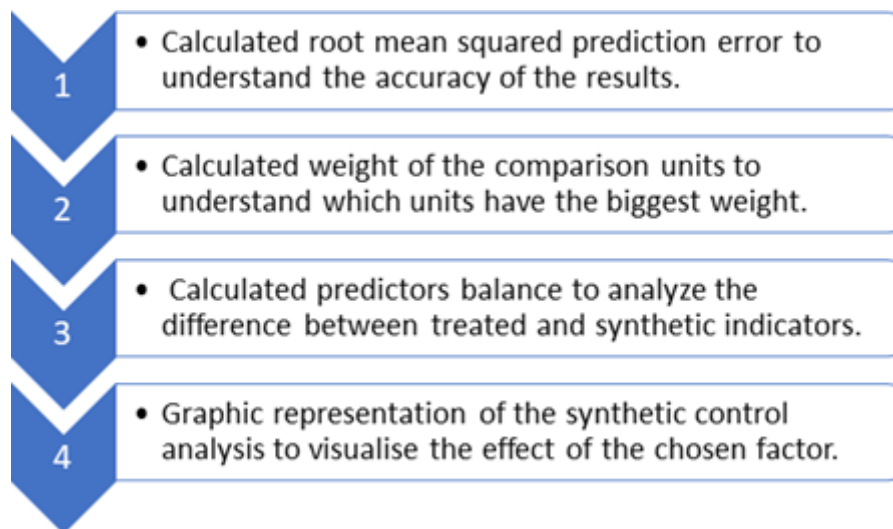


Figure 2. Synthetic control results

Source: Author's evaluation based on STATA synth package

The effect of the chosen factor is shown on the graph. The graph has two lines: a solid one and a dotted one. The solid line represents the analyzed indicator dynamics (for example, a growth of GDP per capita). The dotted line is the synthetic indicator change that shows the dynamics of the analyzed indicator without a chosen factor (for example, the tobacco consumption without anti-tobacco law implementation). The effect is measured as a distance between solid and dotted lines.

In the case of the analysis of the causal impact of science and technology parks on economic growth, it is necessary to create a suitable variable identification. For the synthetic control method, it is required to have one country that has a science and technology park (Belarus) and several countries that do not have it. According to the Internet search engines data, most of the countries have science parks, however, some of them are not functioning and/or do not have an effect on the economy. However, we should take into consideration the fact that with a big number of potential controls the synthetic control method may drop most of them as it aims to build a model as close as possible to the treated unit. For example, in the California research paper, most US states used in the model got a zero weight and were omitted in the final model (Abadie, A et. al., 2010).

For synthetic control analysis, it is important to choose the correct treatment period. In this research, it is needed to check 2 treatment period (2005 and 2001): as the HTP was created in 2005, however, the anticipation of the changes started in 2001 with the digital transformation of the society may also have a causal impact on economic growth.

The analysis will be done using the period from 1997 to 2017 (at the moment of the research the data is available only until the year 2017). In the case of Belarus, the full data is available from 1991, however, due to the deep economic crisis in the country after the Soviet Union collapse (1991), it is not possible to use the period from 1991 to 1996 in the synthetic control, as the results will be biased due to economic shocks.

Based on the analysis of the data available on the Internet the following countries were chosen for the analysis:

1. Belarus
2. Ukraine
3. Moldova
4. Uzbekistan
5. Albania
6. Montenegro
7. Tajikistan
8. Kyrgyz Republic

The above-mentioned countries (except Belarus) in the period from 1997 to 2017 did not have any science and technology parks that fit the definition mentioned in the Terminology Section, so they can be used for the analysis.

Additional criteria for choosing certain units is control units' similarity to the treated one. In the Belarusian case, Moldova, Uzbekistan, Ukraine, Tajikistan, and the Kyrgyz Republic were chosen as these countries together with Belarus were members of USSR and had similar crisis period after the Soviet Union collapse. Meanwhile, economies of Albania and Montenegro are comparable with the Belarusian one. Therefore, we can say that this dataset is valid for synthetic control method usage.

The synthetic control method analysis will be performed using the data collected from the World Bank database.

3.2 Data description.

The success of the synthetic control method in many aspects depends on the data collected and on the identification of the predictors. The key to successful analysis is finding the correct indicators.

During the preparation for the modeling, several combinations of the indicators were tested in order to find the correct set of predictors, as for the precise results of the synthetic control, it is necessary to apply different models to understand the best combination of the indicators.

For each country, the data of the various predictors was gathered for synthetic control analysis.

The detailed information about the data can be found in Table 2.

Table 2. Data description

Indicator	Description	Source and measurement
GDP	Gross domestic product	World Bank, current US\$
GDP per capita	Gross domestic product per capita, economic growth measurement	World Bank, constant US\$
Trade openness	Trade openness = (Import + Export)/GDP	Manually calculated by the author using the World Bank data.
Inflation rate	Inflation rate during the chosen year (GDP deflator)	World Bank, %
FDI rate	The percentage of foreign direct investments from GDP	World Bank, % from GDP
Service export share	The share of services exported for the chosen year in GDP	Manually calculated by the author using the World Bank data, %.
ICT services export	Export of services in the sphere of Information and communications technology	World Bank, %
Export	The amount of export for the chosen year	World Bank, current US\$
Import	The amount of Import for the chosen year	World Bank, current US\$
GFFC	Gross formation of fixed capital	World Bank, %
Labor	Total labor force in the country	World Bank
High-tech export	Total of all high-tech exported in the country	World Bank, current US\$
Grants for tech cooperation	Total amounts of grants provided for technical cooperation	World Bank, current US\$
Industry share	Total industry share from GDP	World Bank, %
Tertiary education	The level of population tertiary education from total	World Bank, %

Source: author's formulation based on the World Bank Open Data (n.d.).

3.1 Synthetic control comparative analysis

The synthetic control comparative analysis is performed in STATA using the *synth* package. Before running the code, the data preparation is performed. All variables were converted to numerical and all missing values were replaced with NA.

Each indicator was given a name suitable for STATA requirements (see Table 3):

Table 3. STATA indicators description

Indicator	STATA name
GDP	GDP
GDP per capita	gdpcap
Import	Import
Export	Export
Trade Openness	Openness
Export of services	ServiceGDP
Level of tertiary education	EDU
Inflation rate	Inflation
Grants for technological cooperation	Cooperation
Industry Share	IndustryShare
Labor force	labor
Export of high-tech	TechEx
Gross formation of fixed capital	GFFC
FDI rate	FDI
Export of ICT	ICT

Source: author's elaboration

4. Results & Discussion

Before performing the synthetic control analysis, it is useful to summarize the data. A full data summary is represented by the number of observations, mean value, standard deviation, and maximum and minimum values of each indicator. From the period from 1997 to 2017 168 observations are available for performing the synthetic control analysis.

The analysis is done by using the following set of indicators and with 2005 (HTP creation) as a treatment year:

- Trade openness
- Tertiary education share
- FDI rate
- ICT Export
- Service Export
- GFFC

Performing the first step of the synthetic control shows that the data was set up successfully. The dependent variable is GDP per capita explained by trade openness, FDI rate, inflation rate, industry share from GDP, and tertiary education rate. Also, in the model were added indicators of GDP per capita for years 1998, 2001, and 2003. Predictors are averaged for the pretreatment year, except above-mentioned years for GDP per capita.

After the data is set, STATA automatically performs nested optimization. Then the root means square prediction error (RMSPE) is calculated. RMSPE is the measure of discrepancy between the path of the result variable for Belarus and its synthetic version. It is used as a recommended measure of the quality of the correspondence between the treated and synthetic units. RMSPE can be expressed by the following general formula adapted to a particular case where T stands for the pre-treatment period (see Formula 2):

$$\text{RMSPE} = \left(\frac{1}{T_0} \sum_{t=1}^{T_0} (Y_{jt} - Y_{jt}^*(h))^2 \right)^{1/2}$$

Formula 2. RMSPE

Source: Abadie et al., 2012, Cerulli, 2017

RMSPE of the chosen model is 148.0685 meaning that there is a high probability of an error for the model of indicators chosen.

Nevertheless, the unit weights should be checked to understand which country has the biggest weight in the chosen model. We can see that Albania has the biggest weight in this model (see Table 4). All units with insignificant weights were automatically equated to zero.

Table 4. Unit weights.

State	Weight
Ukraine	0
Moldova	0
Uzbekistan	0
Albania	.748
Montenegro	.252
Tajikistan	0
Kyrgyz Republic	0

Source: author's calculations

The predictors' balance demonstrates the affinity between the treated indicators and their synthetic version (see Table 5).

Table 5. Predictors balance.

Predictors balance		
	Treated	Synthetic
Trade Openness	136.5	36.5655
Tertiary Education Share	104.25	32.644
FDI	45.875	103.705
ICT Export	90.75	103.3605
Service Export	32	75.4975
GFFC	86.875	104.795
GDP per capita in 1998	2608.675	2702.968
GDP per capita in 2001	3030.948	3091.77
GDP per capita in 2003	3453.964	3340.309

Source: author's calculations

In the synthetic control method, the effect is a distance between the treated unit line (actual Belarus) and synthetic control unit line (Belarus without the HTP). The important aspect is that the lines are matching before the pretreatment period as it means that the results are precise.

From the graph (see Figure 3) we can see that without the HTP Belarusian GDP per capita would be lower than the current one (dotted line).

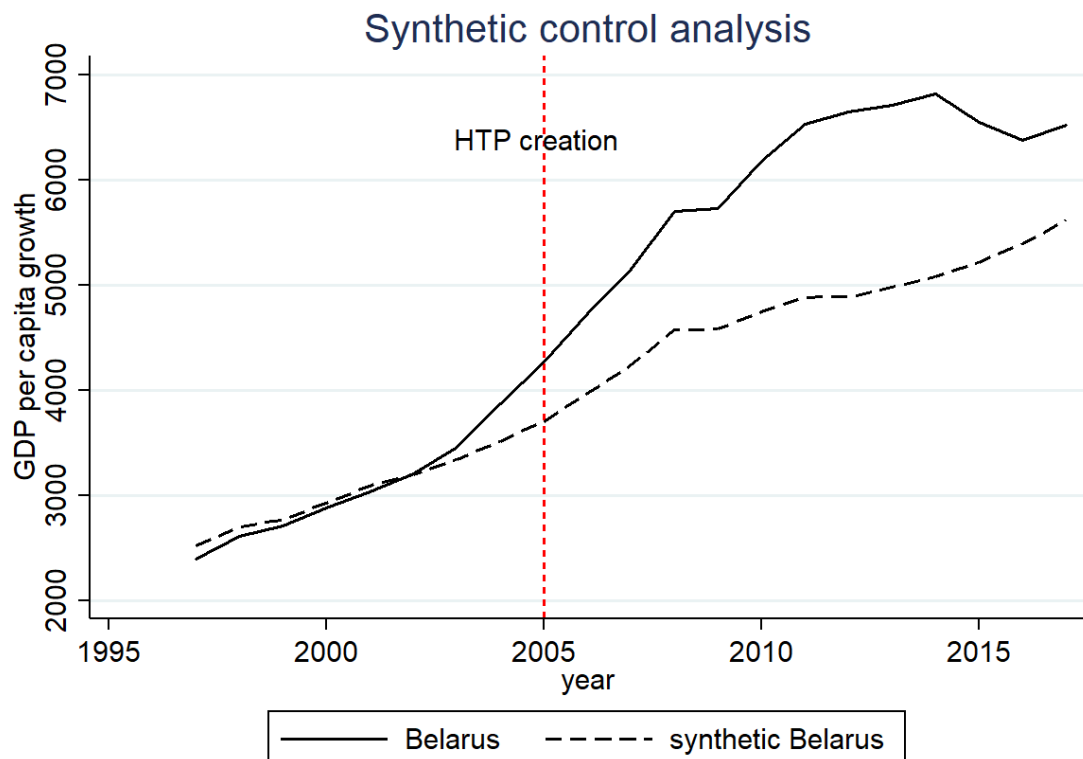


Figure 3. Synthetic control results, 1st run, the treatment year 2005.

Source: author's calculations

The common way to check the results is the structural break test that allows determining when there is a significant change in the chosen dataset (Tests for structural breaks in time-series data, n.d.). For the structural break test, the same model should be applied. The structural break test is performed with the following H0 hypothesis: *no structural break in the dataset*. The structural break test cannot be used for the multipanel data, so only Belarus should be analyzed. For the chosen unit only 21 observations are available. The test can be performed in 2 ways: with unknown and known break years. Due to the small dataset, the STATA can perform the test only with 35 trim level for unknown structural break period. It means that it can analyze period only from 2005 to

2010. In this case, the performing of the structural break test is not possible. After attempting to perform the structural break test with known break year (2001 and 2005), the same problem occurred: as the dataset is small, the test cannot be performed.

Thus, the results can be using other methods common for causality analysis, for example with the placebo test.

As the synthetic control result (see Figure 3) also demonstrated that the lines before the treatment period are not matching meaning that the effect is not well-calculated, the change of the model is required. From the first results of the synthetic control analysis, it is visible that the effect emerged before 2005. In this case, we can talk about the anticipatory effect. As there was an anticipation of the economic growth before 2005 we can move the treatment period to several years before.

The anticipatory effect can be explained by the Infopark opening in December 2001 that created favorable conditions for the IT development in the country and, basically, was a foundation for the HTP creation. After moving the treatment period to 2001, the results of the synthetic control should be precise.

To check this hypothesis, it is needed to change the treatment year to 2001. The same predictors should be used for comparison; however, it is needed to change GDP per capita years that will not be automatically averaged by STATA. Considering the small pretreatment period, only 2 years should be used for the analysis (first year of the pretreatment period and the last one).

After running the same model with GDP per capita not averaged for the years 1997 and 2000, the results demonstrate that changing the treatment year to 2001 significantly decreases the value of RMSPE (21.7957). This way the error probability is decreased and the results became more precise.

With the precise results, two countries have weight, and Albania has the biggest weight (see Table 7). Based on the unit weight we can see that the HTP effect is best reproduced by the combination of Albania and Montenegro.

Table 7. Unit weights, 2nd run

State	Weight
Ukraine	0
Moldova	0
Uzbekistan	0
Albania	.775
Montenegro	.225
Tajikistan	0
Kyrgyz Republic	0

Source: author's calculations

Table 8 shows the predictors balance for the model with the treatment year of 2001 and demonstrates the significant difference between treated and synthetic trade openness tertiary education share, and FDI indicators (see Table 8).

Table 8. Predictors balance, 2nd run.

Predictors balance		
	Treated	Synthetic
Trade Openness	128.25	37.63125
Tertiary Education Share	97.75	41.91875
FDI	61	86.475
ICT Export	90.25	91.925
Service Export	24.25	52.0125
GFFC	98.25	90.5
GDP per capita in 1997	2395.109	2427.494
GDP per capita in 2000	2879.38	2853.689

Source: author's calculations

The graph clearly demonstrates that the results are precise (see Figure 5). The effect is calculated as a distance between Belarus (treated unit) and synthetic Belarus (synthetic control unit). We can see that immediately after the treatment year, the two lines begin to diverge noticeably. There is a significant difference in the growth rate in

Belarus and its synthetic version. The discrepancy between the two lines suggests that there is a positive impact of HTP on GDP per capita.

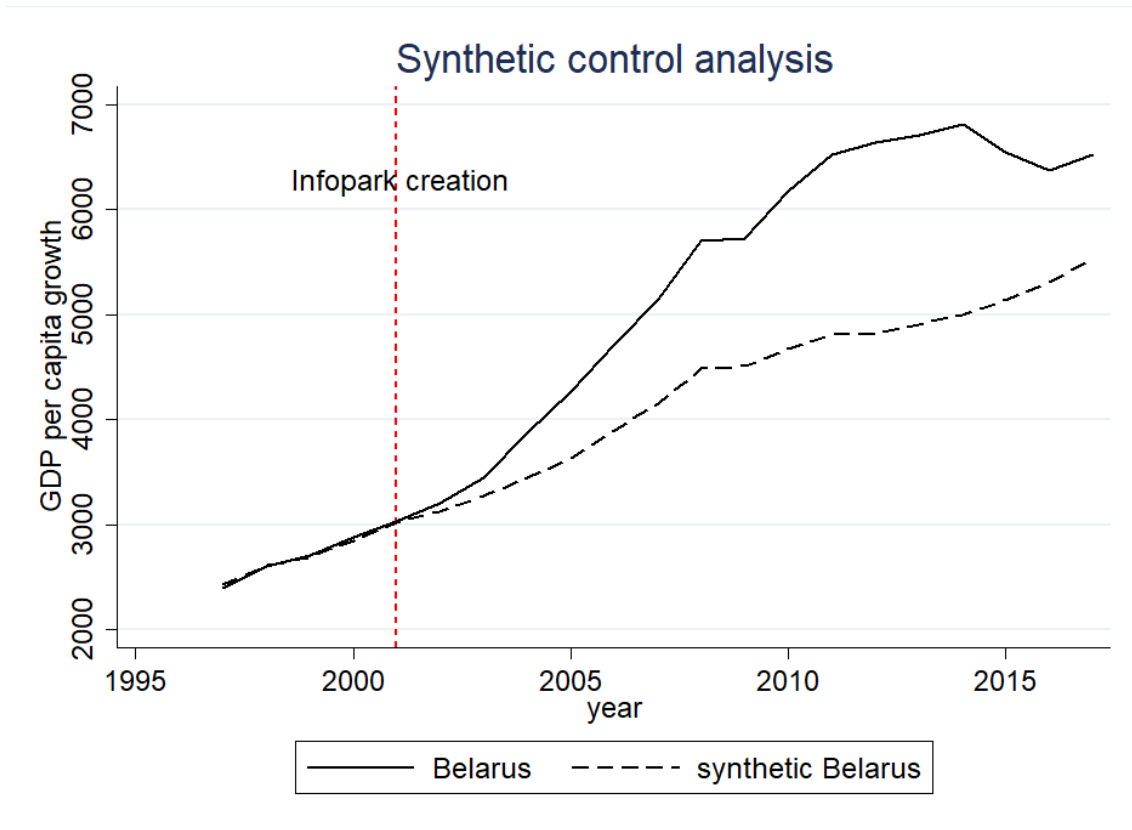


Figure 5. Synthetic control results, 2nd run, the treatment year 2001.

Source: author's calculations

The results have to be evaluated for its significance. It can be done by using the placebo test. The placebo test is the application of the synthetic control method to countries that did not have STPs in the analyzed period. If the placebo test demonstrates a gap of a magnitude similar to the one estimated for Belarus, then the results do not prove the positive impact of HTP on economic growth in Belarus. And, on the contrary, if the placebo test shows that the gap estimated for Belarus is large relative to the gaps for the countries that did not have STPs, then the results provide the significant evidence of a positive impact of STPs on economic growth.

For the placebo test, the same model is applied for other 7 countries to estimate the effect. The placebo test shows that there is a significant gap between the results of Belarus and other countries proving that the positive effect in Belarus was caused by the science and technology park.

For example, synthetic control analysis results for Ukraine (see Figure 6) demonstrate the following GDP per capita:

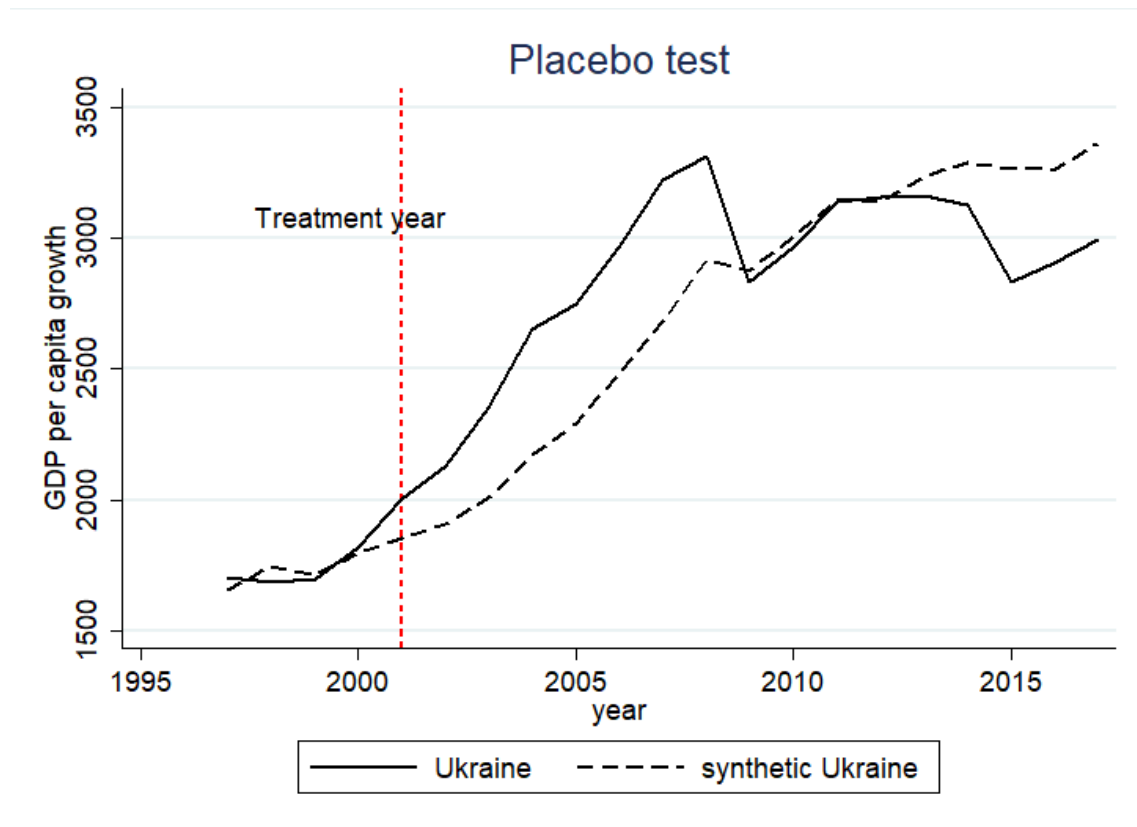


Figure 6. Placebo test. Ukraine results, the treatment year 2001

Source: author's calculations.

Placebo test for Moldova showed the following GDP per capita change (see Figure 7):

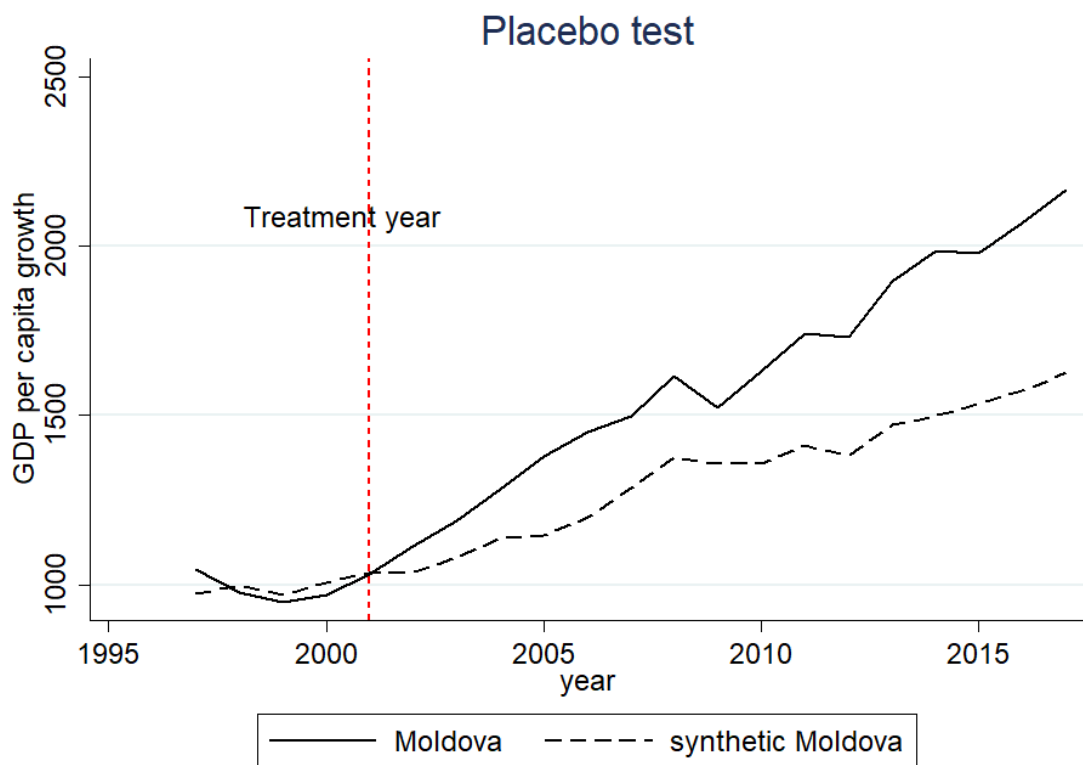


Figure 7. Placebo test. Moldova results, the treatment year 2001

Source: author's calculations.

Results for all units can be represented by the graph (see Figure 8) where the orange line (marked with star, *) represents the effect for Belarus and grey lines shows the effect for other countries. The results are shown as a difference between treated units and their synthetic versions.

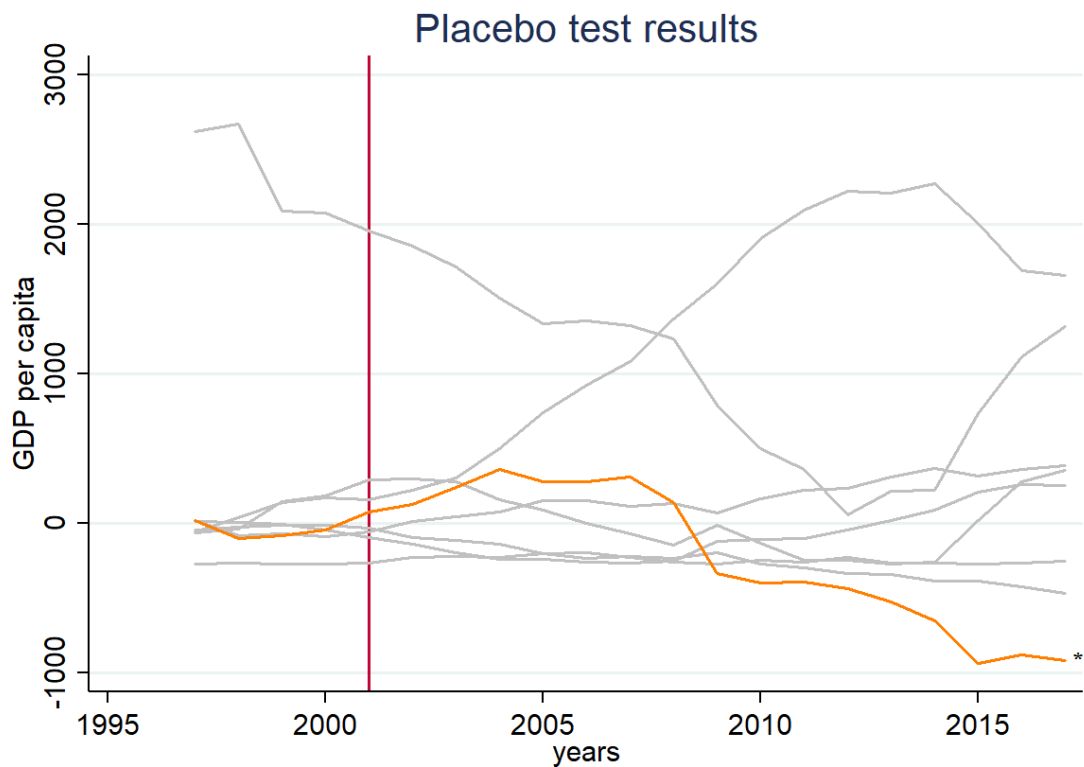


Figure 8. Placebo test results for all units, the treatment year 2001

Source: author's calculations.

We can see that the synthetic control unit line does not have the same magnitude (compared to Belarusian one). It proves the assumption that the changes in GDP per capita are explained by the existence of STPs.

In some cases, the results can be biased due to economic shocks or severe political changes. However, in 2001 the economy of Belarus was stable, and no economic shocks were observed. In the case of Belarus, special attention should be paid to the increase of export volumes with the main trade partner (Russia), however, the active trade with Russia started in 2004 meaning that GDP per capita break in 2001 was not caused by export volumes (Ministry of Finance of the Republic of Belarus, n.d.).

The results of the synthetic control analysis prove the following hypothesis: STPs have a positive impact on the economic growth of the country. And we can conclude that the STPs are one of the factors that have a causal impact on GDP per capita growth.

5. Conclusion

The research demonstrates that science and technology parks have a positive impact on the economic growth of the country. The case of Belarus proves that science and technology parks can be the instrument of economic development for countries with transitive and developing economies.

The active governmental support of the IT sector including legal and tax preferences creates favorable conditions for STPs development in the country and can cause the anticipatory effect for economic growth.

STPs can significantly increase the volume of foreign direct investments in the country and stimulate trade openness.

The research demonstrated that positive effect can be achieved via legal changes and creation of favorable conditions for IT development, a positive impact of STPs started in 2001 due to the Infopark creation and developing a strategy for the informatization of the society.

Based on the analyzed case of Belarus, we can see that the IT sphere plays an important role in the economic and social transformation of the country. State support of the IT sector creates favorable conditions for STPs development.

Based on the research the following recommendations can be given to increase economic growth using STPs development:

1. Create favorable conditions for IT development in the country.
2. Provide tax and legal benefits for the companies registered as park residents.
3. Develop special laws regarding IT and technoparks development in the country.
4. Provide governmental support for the science park creation and development.

The Belarusian comparative analysis demonstrates that the development of the IT sphere in the country can be the key instrument of economic growth.

The case of Belarus can be applied to other countries with transitive economies.

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