Section 5. Regional economy

https://doi.org/10.29013/EJEMS-22-2-52-67

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IMPACT OF THE REGIONAL TECHNOLOGY DEVELOPMENT AND INNOVATION ON THE UKRAINIAN LIGHT INDUSTRY'S EXPORT

Abstract. Empirical data refers to the light industry's export and indicators of the regional technology development and innovation (RTDI) including the technological and innovative activity, expenditure on innovation and R&D, its implementation and taxes in 25 Ukrainian regions from 2012 to 2019. The research methodology consists of: regression analysis to detect linear interactions; the spatial analysis to investigate spatial relations; the Hausman test to confirm the coherence of the random effect; difference-in-differences (DID) technique to calculate the impact of tax-free policy. The research verifies justification of the centralized policy on the digitalization and innovative transformations for the Ukrainian light industry.

Keywords: innovation, Ukrainian light industry, spatial analysis, difference-in-differences.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or non-for-profit sectors.

1. Introduction

The light industry in Ukraine involves three groups: 1) textiles: 2) apparel; 3) leather and footwear. In 2020 the industry is represented by more than 2.5 thousand enterprises engaging about 88 thousand employees [1]. However, it faces a constant decline in production and exports, which aggravated during the COVID-19 period. Thus, the domestic production index decreased dramatically by 19.4% for 2020 comparing to the corresponding period of 2019 (Figure 1), while the export dropped sharply by 17.6% [2]. Besides, the declining trend in the light industry's performance was observed for 2019, where the export activity and production were less by 9.16% and 9.9% comparing to 2018, respectively [3]. Additionally, the export volume did not exceed 18842.2 thousand USD for 18 regions in January – May, 2020 which referred to 31% of the total light industry's export (Figure 2). Meanwhile, 36.7% contributed by two regions in Western Ukraine which export volume reached more than 49595 thousand USD per region in the reporting period [4].

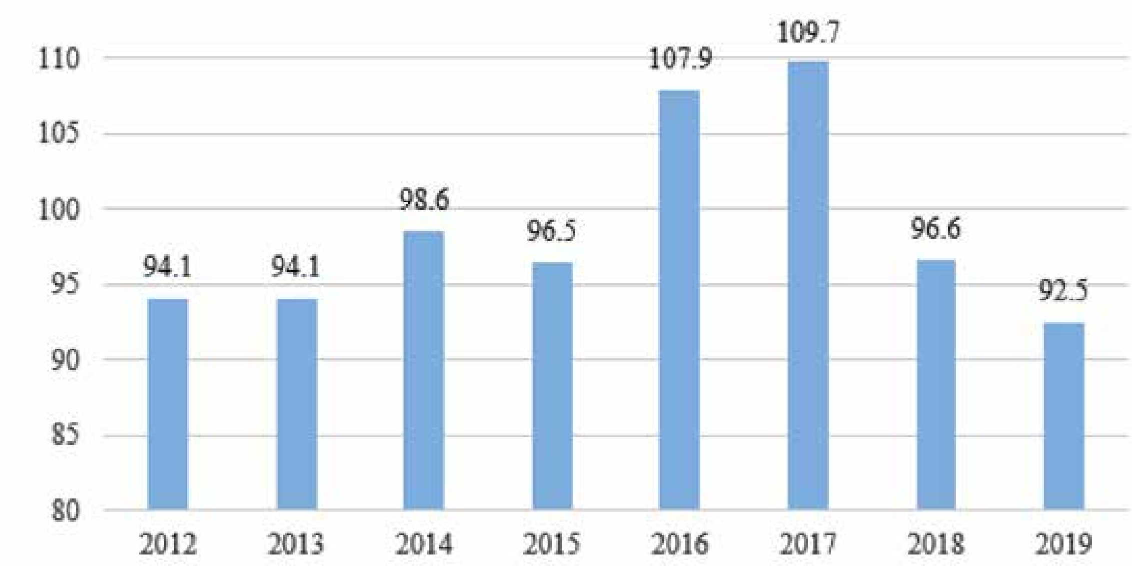

Figure 1. The Ukrainian Light Industry's Production Volume from 2012 to 2019

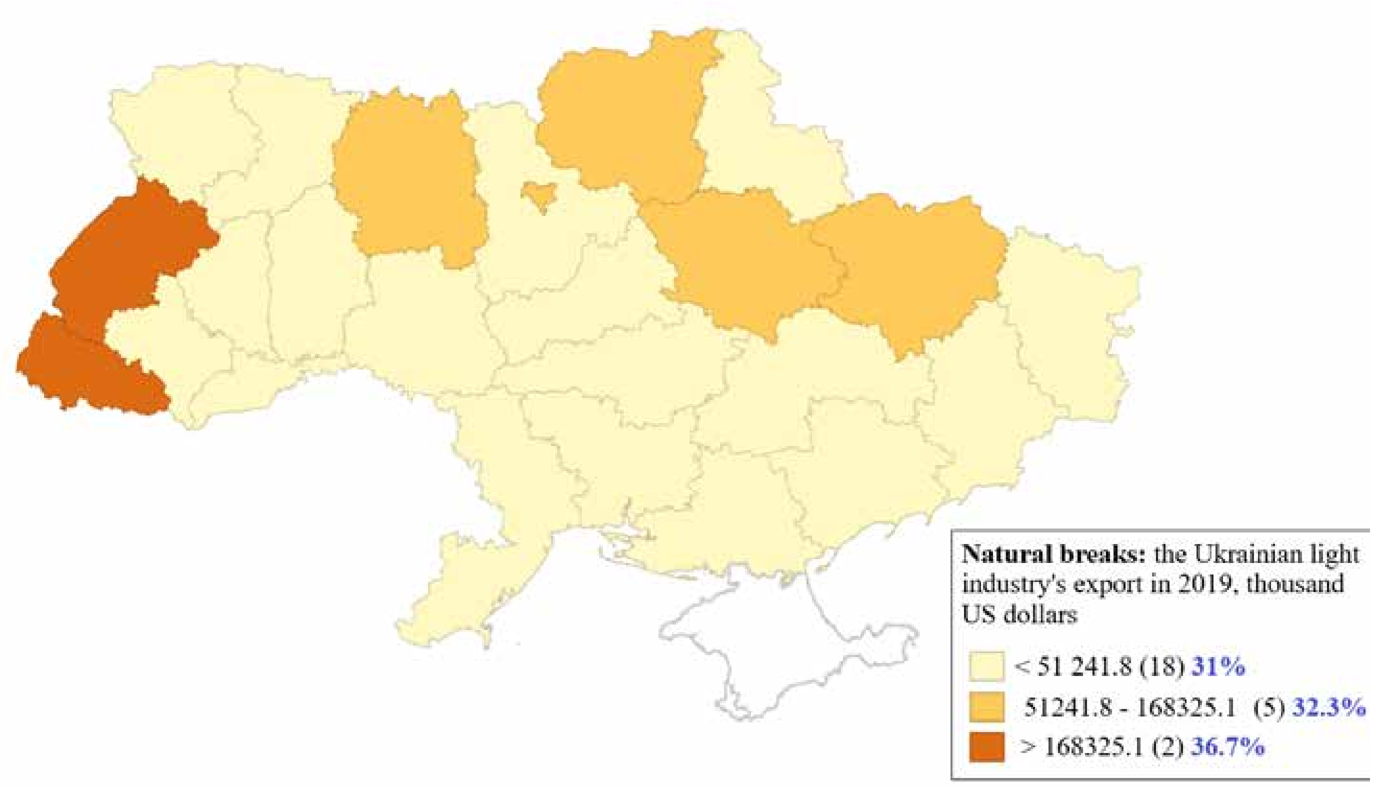

Figure 2. The Regional Distribution of the Light Industry's Export in 2019

The critical condition of the light industry in Ukraine draws the special attention of researchers who emphasize the need for the urgent technological and innovative re-equipment of the industry as the primary concern [5–12]. Also, the development path of the Ukrainian light industry remains an acute issue to the government and the Association of enterprises of textile and leather industry which cooperate to prepare a law "On promotion of digitalization and investment attractiveness of light industry enterprises" (N2508) [13]. First, the law involves establishing a zero value added tax (VAT) rate on equipment imported to Ukraine for production needs. Second, it exempts the light industry enterprises from the income tax referring to the main activities. The law came into force in April, 2020 and planned for 10 years. The released funds (tax amounts that are not paid to the budget and remain at the taxpayer's disposal) are used to increase production volumes, capital investments, introduce innovative technical and technological transformations of production, smart technologies, or repay loans used for these purposes [14].

These circumstances provide the motivation for the current research which aims to verify the justification for a centralized national policy on digitalization and innovative transformations in the Ukrainian light industry. Hence, the research objective is to estimate the spatial dimensions of the Ukrainian light industry's export and the intensity of its linkage to the regional technology development and innovation (RTDI).

2. Research Background

2.1. Impact of the Regional Technology Development and Innovation on the Ukrainian Light Industry's Export

The impact of the technology and innovation development on the export and productivity is discussed in the empirical literature. For instance, Lai et al. [16] prove that new technologies and innovations promote the higher firms productivity within the research conducted in China. Also, Omer et al. [17] determine the significant positive relationship between the technology transfer and company performance which is mediated by innovation in Turkish export enterprises. In addition, Lecerf and Omrani [18] have found out that the developing innovation including the increasing level of IT promotes the internalization of small and medium-sized enterprises in Germany, while those findings are characterized as country-specific. Additionally, Ferreira et al. [19] identify the impact of the technology transfer on the economic growth considering the cross-continent level and investigating Europe and Oceania. Ferreras-Méndez et al. [20] determine that the relationship between export performance and knowledge transfer is mediated by absorptive capacity in the context of Spain. Bezpalov et al. [21] develop a model for managing innovation-driven development within the regional industrial complex in Russia aiming to boost the competitiveness of products or service and ensure the economic growth. On the other hand, Sharma [22] identifies that technology transfer is not significant determinant of export in the context of Indian manufacturing. However, companies selling single product significantly benefit from both export and technology transfer.

Then, in the context of the light industry previous research indicates beneficial results of implementing technology and innovation. Thus, Blekanov et al. [23] identify the applicability of big data analysis of social media, namely, Twitter, in terms of revealing and ranking of supply chain risks in the footwear industry. Khvorostyanaya [24] proves the feasibility of technology transfer association industrial strategy development program to promote the competitiveness of the fashion, apparel and textile industries in Russia. In addition, Akter [25] develops an effective technology transfer mechanism for the textile and apparel industry in Bangladesh by utilizing innovative capacity analysis. Also, Pal & Yasar [26] design a blockchain-based architecture of distributed data maangement based on the Internet of Things aiming to support transaction services within a multilateral apparel industry supply chain network. Then, Küsters et al. [27] develop the plan of the Industry 4.0 application within setting up the textile factory in Germany.

In terms of the Ukrainian industry the problem of the technology development and innovation remains acute and actively discussed. Atamanov et al. [28] determine the growth of the innovation activity during the production downturn as the mechanism of overcoming the crisis. Dzhedzhula & Yepifanova [29] determine the relationship between the innovative activity and the growth of the and the company competitiveness in the context of the Ukrainian industry. Then, Grabovskaya [30] proposes a mechanism of the improvement for the innovative activity of business entities in Ukraine through the influence of the government. Also, Zilinevich & Galushchak [31] identify factors affecting the Ukrainian industry innovation development including the imbalance of the financial and credit policy, poor infrastructure, shortage of domestic raw materials, high environmental risks, inflation. Finally, Kravchuk [32] discuss the implementation of the concept Industry 4.0 within the Ukrainian industry. Regarding the Ukrainian light industry, the mechanism of its application is developed by Fedak [33].

Therefore, there is a lack of research concerning the practical implication of technology and innovation in terms of the Ukrainian light industry. Furthermore, the previous recommendations do not consider the current state of the regional industry development and existing technological resources.

2.2. Current State within the Ukrainian Light Industry

The Table 1 summarizes key issues determined by the empirical literature. First, the industry suffers from difficulties in attracting staff [6, 7, 34, 35]. It is also complicated by the external migration to countries of the European Union. Since 2017 the labor migration to Europe increased dramatically due to the visa-free regime and the open-door policy for the labor force from Ukraine in Poland, Czech Republic, Lithuania, Latvia, and Estonia. Second, the industry faces difficulties in obtaining funding to improve the technology and increase capacity [7, 34]. Third, it faces troubles within accessing external markets through the mismatch of standards, the lack of the experience and activity [34, 35].

Fourth, the domestic purchasing power is low that results in decreasing of the growth rate of light industry by 4.6% in 2019 [7, 34, 36]. Fifth, the light industry suffers from poor reputation of Ukraine as a place to invest or find suppliers due to corruption, mistrust of the legal system and war in the East [7,34]. Sixth, the light industry is characterized with the low productivity due to lack of technical skills, the technology and infrastructure [6, 7, 34]. Seventh, the Ukrainian light industry is dependent on the import of raw materials [7, 34].

Table 1.– Key Issues and Directions for the Ukrainian Light Industry Development

Direction	**Authors**	**Issue**	**Authors**
1	***2***	***3***	***4***
Creating regional clusters	Dudko, 2019 Havrylenko and Brodiuk, 2018 Rubin and Tkachenko, 2017 Zheliuk and Berestetska, 2019	Lack of the qualified staff	Dudko, 2019 Havrylenko and Brodiuk, 2018 Rubin and Tkachenko, 2017 Selivestrova and Parhacka, 2018
Improving the tax and credit policy	Havrylenko and Brodiuk, 2018 Selivestrova and Parhacka, 2018	Lack of funding for the technological re-equipment	Olyinyk et al., 2019 Rubin and Tkachenko, 2017 Selivestrova and Parhacka, 2018
Supporting the national brand	Boiko and Tarasova, 2019 Zheliuk and Berestetska, 2019		
Implementing the foreign experience	Kasyan, 2016 Rubin and Tkachenko, 2017	Mismatch of the standards within	Havrylenko and Brodiuk, 2018 Rubin and Tkachenko, 2017

1	2	3	4
Strengthening the government control and the legal support	Boiko and Tarasova, 2019 Olyinyk et al., 2019	accessing the external market	
Enhancing the investment image	Kasyan, 2016 Olyinyk et al., 2019	Unfavorable investment climate	Rubin and Tkachenko, 2017 Selivestrova and Parhacka, 2018
Promoting the technology transfer and innovation	Kasyan, 2016 Olyinyk et al., 2019 Zheliuk and Berestetska, 2019	Low productivity	Boiko and Tarasova, 2019 Dudko, 2019 Rubin and Tkachenko, 2017 Selivestrova and Parhacka, 2018
Reasonable consumption and smart utilization	Olyinyk et al., 2019 Zheliuk and Berestetska, 2019	Import-dependence	Boiko and Tarasova, 2019 Olyinyk et al., 2019 Rubin and Tkachenko, 2017 Selivestrova and Parhacka, 2018 Zheliuk and Berestetska, 2019

Consequently, the Ukrainian light industry generates relatively low revenues and its position is far behind the world's top light industry exporters. On other hand, it cooperates with a large number of related industries and serves the entire economic complex of the country. Therefore, the researchers consider that it has a powerful production potential and capable of producing an extensive range of widely used industrial goods and it can be revived due to various measures (Dudko, 2019; Havrylenko and Brodiuk, 2018; Kasyan, 2016; Rubin and Tkachenko, 2017; Selivestrova and Parhacka, 2018).

Although, the idea of creating cluster prevails in the empirical literature, other measures to revive the Ukrainian light industry proposed by the literature are summarized in accordance with the problem which they might solve in the Table 1.

Herewith, the most cited directions to revive the Ukrainian light industry include the following measures. First, creating regional clusters is often considered as one of the direction to attract the qualified staff [6, 7, 10, 34, 35]. The idea of clustering the Ukrainian industry draws the attention of the government and scholars. Hence, the process of creating clusters in Ukraine is regulated by State strategy for regional development for the period up to 2027 written by the Cabinet of Ministers in Ukraine [37].

Also, several textile industry clusters are already established, such as Ukrainian Fashion Cluster, Fashion Globus Ukraine, Kharkiv Fashion Cluster and West Ukrainian Fashion Cluster. The project of the clothing cluster in Khmelnytskiy region in West Ukraine is proposed [38].

3. Research Area and Methodology

3.1. Characteristics of Panel Data

After determining the research objective and tasks, the process of collecting data is initiated. The sample includes the panel data on the light industry's export and RTDI in the Ukrainian regions regarding the time period from 2012 to 2019. The Table 2 represents characteristics of the primary data.

Hereby, the value $Export_{in}$ is the average amount of the light industry's export in the region *i* in the year *n*. Then, the value of RTDI involves three dimensions. The first one is the technology and innovation activity A_{in} represented by the quotient of staff engaged in R&D and number of innovative enterprises in the region *i* in the year *n*.

Table 2. – Characteristics of Panel Data

Variable	Indicator	Formula	Measure
Dependent variable (Y):			
$Export_{in}$	The average amount of the light industry's export in the region *i* in the year *n*	–	10^3 hryvna
Explanatory variables (X):			
Determinants related with regional technology development and innovation (RTDI):			
A_{in}	The technology and innovation activity in the region *i* in the year *n*	$\frac{Staff\ engaged\ in\ R\&D}{Number\ of\ innovation\ active\ enterprises}$ (3.1)	Employees per enterprise
E_{in}	The expenditure on R&D and innovation in the region *i* in the year *n*	$Expenditure\ on\ R\&D + Expenditure\ on\ innovation$ (3.2)	10^3 hryvna
I_{in}	The implementation of R&D and innovation in the region *i* in the year *n*	$\frac{Innovation\ products\ sold}{Enterprises\ implementing\ innovations}$ (3.3)	10^3 hryvna per enterprise
Tax- related deteminants:			
VAT	Value-added tax		%
IT	Income tax		%

The second component E_{in} is the sum of the expenditure on R&D and innovation in the region *i* in the year *n*. Finally, the implementation of R&D and innovation I_{in} refers to the quotient of the innovation products (goods, services) sold and the number of enterprises implementing innovations in the region *i* in the year *n*. The data concerning the regional export and RTDI is gathered from State Statistics Service of Ukraine (2020 b).

Finally, tax-related determinants include value-added tax (VAT_n) and income tax (IT_n) which are paid by enterprises. The primary data for these two variables consider annual tax rates.

3.2. OLS regression model

The dependent variable is the light industry's export. The independent variables include three measures of the RTDI such as technology and innovation activity, expenditure on R&D and innovation, implementation of R&D and innovation. The OLS regression model is presented below:

$$\ln Export_{in} = \beta_0 + \beta_1 \ln A_{in} + \beta_2 \ln E_{in} + \\ + \beta_3 \ln I_{in} + \beta_4 \ln VAT_n + \beta_5 \ln IT_n + \varepsilon \quad (3.4)$$

Where $Export_{in}$, A_{in}, E_{in}, I_{in}, (VAT_n), (IT_n) are described as above; β_0 identifies a constant; β_{1-5} is a slope coefficient for each independent variable; ε refers to the normally distributed error. The natural logarithm (ln) is applied to normalize the values.

Meanwhile, if the spatial correlation (autocorrelation) exists, i.e. the values identified in one region are associated to observation in other regions, then the OLS model might be inappropriate tool to capture the spatial interdependence. However, the endogeneity problem is eliminated by extending the OLS model with spatially endogenous interaction. So the OLS is transformed into the spatial autoregressive model (SAR) which assesses the spatial dependence of the predicted values across regions. Also, omitting the relevant covariates in the OLS model, which are correlated with variables from other regions, causes the spatial correlation in the error term. This problem might be solved by extending with the spatial interactions in residuals and modifying the OLS into the spatial error model (SEM).

3.3. Spatial analysis

The spatial analysis involves three models. It aims to test hypotheses about the spatial interactions for endogenous and exogenous variables. The relationships within those three modifications of the spatial model are represented in the Figure 3.

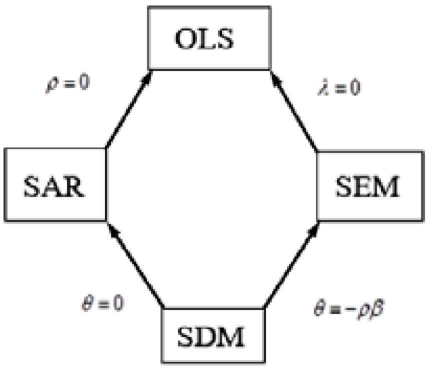

Figure 3. The Relationship Between Different Spatial Dependence Models

Based on the research background, the Hypothesis 1 is stated:

H1: *the regional technology development and innovation expressed by values of the technological and innovation activity, expenditure and implementation in a region impact (or are related to) the value of the light industry's export in neighboring regions in the context of Ukraine.*

The SDM is developed to test Hypothesis 1. It consists of the spatially lagged dependent variable and spatially lagged explanatory variables. The SDM is specified as follows:

$$Y_{in} = \rho WY + \alpha_{l_n} + \beta X_{in} + WX\theta + \varepsilon \qquad (3.5)$$

Where Y_{in}, X_{in} are identified as above, β is slope coefficients for each explanatory variable; l_n is a vector associated with the constant term parameter α to be estimated; ρ refers to a spatial autoregressive parameter; WY is the spatially lagged Y calculated for various spatial dependencies with W defined as $(i$ x $i)$ spatial weight matrix; ρWY is an endogenous interaction effect; $WX\theta$ is exogenous interaction effect.

Then, modifying the SDM into different spatial regression specifications is able to test the hypothesis about the existence of a spatial spillover (Le Sage and Kelley Pace, 2009). The second hypothesis is generated:

H2: *the value of the light industry's export in a region impact (or are related to) the value of the light industry's export in neighboring regions in the context of Ukraine.*

To test this hypothesis SDM might be simplified into the spatial autoregressive model (SAR), where $\theta = 0$, also called the spatial autoregressive model (SAR), which is presented below:

$$Y_{in} = \alpha_{l_n} + \beta X_{in} + WX\theta + \varepsilon \qquad (3.6)$$

Finally, the third hypothesis is defined as follows.

H3: *other factors not included in the model might affect (or to be related to) the residuals in neighboring regions in the context of Ukraine.*

Thus, to test this hypothesis, the SDM degenerates into the spatial error model (SEM), where $\theta = -\rho\beta$, then $\lambda = \rho$, which is demonstrated as follows:

$$\begin{aligned} Y_{in} &= \alpha_{l_n} + \beta X_{in} + u \\ u &= \lambda \bar{W} u + \varepsilon \end{aligned} \qquad (3.7)$$

Where u is used to model the disturbances.

The spatial weight matrix which defined as at Eilers (2019), it is calculated before running spatial models:

$$w = \begin{pmatrix} w_{11} & w_{12} & w_{13} & \cdots & w_{1m} \\ w_{21} & w_{22} & w_{23} & \cdots & w_{2m} \\ w_{31} & w_{32} & w_{33} & \cdots & w_{3m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ w_{m1} & w_{m2} & w_{m3} & \cdots & w_{mm} \end{pmatrix} \qquad (3.8)$$

Where m refers to the number of observation.

Meanwhile, the queen and the rook contiguity matrixes are the same due to the geographical location on the Ukrainian regions. Thus, only one spatial weight matrix is applied in the context of the research.

3.4 Hausman Test

First, the difference between random- and fixed-effects is clarified. As stated by Vaisey and Miles [41], the key difference between the fixed-effects and random-effects model infers in the correlation between the observed value and the unobserved time constant effects. Also, Bell et al. [42] claim about the incoherency of the fixed-effects model in regards to evaluating the parameters which are biased by violations of normality. Therefore, fixed effects remain unaltered within the sample, while random effects might change across cases omitting variables inconsistently.

A choice between the random- and fixed-effects models is feasible by the Hausman test applied when both models can be run for the panel data [43]. Herewith, the null (H_0) and alternative (H_A) hypotheses are examined.

H_0: The random-effects model is rather consistent.

H_A: The fixed-effects model is rather consistent.

Basically, if the correlation between explanatory and control variables is absent, then both fixed- and random-effects model are valid, while fixed-effects model is inefficient. Thus, the Hausman test is the evaluation for the independence of the λ_i and the x_{kit} which are assumptions for the random-effects model. As a formula the Hausman test is presented as follows:

$$W = (\beta_{RE} - \beta_{FE})' \Sigma^{-1} (\beta_{RE} - \beta_{FE}) \sim \chi^2(k) \qquad (3.9)$$

Where β_{FE}, β_{RE} are estimators for the fixed effects and random effects respectively. Then, the p-valued of the chi-square χ_2 is investigated. Since the p-value is less than 1%, then the null hypothesis might be rejected. By contrast, the random-effect model is considered as consistent if the p-value is more than 1%.

3.5 Difference-in-Differences Method for Policy Impact Evaluation

The DID method is frequently applied technique for policy impact evaluation which is also fully recognized and utilized by the European Commission [44] and the World Bank [45]. This technique incorporates concepts of the cross-sectional treatment-control comparison and then, before-after studies in order to achieve more robust identification. It includes an estimation of the policy impact (so-called, "treatment") by comparing results between the treatment and control groups with the outcomes after the policy implementation.

Basically, DID employs the data from two time periods for two groups. However, the data might be repeated as a panel or cross-sectional samples of population [46]. The DID estimation of the policy impact is formalized as follows:

$$DiD = (\overline{Y}_{i=Treatment,\,t=After} - \overline{Y}_{i=Treatment,\,t=Before}) - \\ -(\overline{Y}_{i=Control,\,t=After} - \overline{Y}_{i=Treatment,\,t=Before}) \qquad (3.10)$$

Where Y with the bar refers to the average value of the outcome variable in the region i in the time period t.

It includes three parameters we estimate potential-outcome means (POM), the average treatment effect (ATE) in population and the average treatment effect on the treated (ATET). In particular, POM assesses the mean value of the outcome for two treated and control periods. ATE evaluates the difference in these two means. According to Lechner [47], ATET might be more reliable in predicting the treatment effect due to its focus on the control group. The formula of the ATET is defined as below:

$$ATET = E[(y_{1i} - y_{0i}) \mid D_i = 1] \qquad (3.11)$$

Where E refers to the expectation operator, y_{1i} is the results of the observed value for the treated group, y_{0i} is the outcome of the control group. D is the target distribution. Thus, the ATE does not involve the target distribution. Meanwhile, the ATE and ATET often differ from each other, while they evaluate outcomes which are not affected from the impact in the same manner.

4. Data Analysis

4.1.OLS Model for the Light Industry's Export

The OLS model for the Ukrainian regional light industry's export is generated by the software IBM SPSS Statistics v.23. The results of the regression analysis are demonstrated in the Table 3 below.

Table 3. – Regression Analysis (Dependent Variable = Exp_{in})

Variables	B	Beta	t-value
Constant	1.536	–	3.200**
A_{in}	0.025	0.013	0.183
E_{in}	0.546	0.670	7.872**
I_{in}	0.173	0.183	2.891**
VAT	–0.120	–0.023	2.561*
IT	0.015	0.065	0.328
R		0.807	
R^2		0.651	
F		98.159**	

$^{**}p < 0.01$, $^{*}0.01 < p < 0.05$

Based on the results of the regression analysis, the model represents the high correlation between the observed and predicted values since the correlation coefficient is 0.807. Also, the model is able to predict the regional light industry export by 65.1%. Herewith, the significant results of the F-test prove that the model fits the sample data. The export is positively and significantly associated with the effect of the regional expenditure on the technology and innovation and its implementation. The Beta-coefficient obtained for the expenditure shows the highest effect on the export comparing to other variables. Meanwhile, the negative direct dependency between export and value added tax is obtained. Hence, the decrease of the tax rate promotes increasing of export activity in the context of the Ukrainian light industry.

Consequently, the direct dependences between observed and predicted variables exist with regard to the expenditure and implementation of technologies and innovation. Also, tax burden influences the Ukrainian light industry's export activity.

4.2. Spatial Analysis

The spatial analysis is generated by Stata v.15. The SDM, SLM and, then, SEM are developed to investigate the spatial interrelations between the light industry's export and the RTDI.

The Table 4 reports results of building SDM with random effects and three dimensions of fixed effects including spatial, time and combined spatial-time effects.

Table 4. – SDM (Predicted Variable = *Export*)

	Random-effects	Spatial fixed-effects	Time fixed-effects	Spatial-time fixed-effects
1	**2**	**3**	**4**	**5**
Constant	1.66 [2.31*]	–	–	–
A_{in}	0.12 [0.86]	0.10 [0.70]	0.25 [1.63]	0.17 [0.98]
E_{in}	0.27 [5.63**]	0.28 [5.18**]	0.21 [2.25*]	0.26 [5.41**]
I_{in}	0.03 [0.76]	0.03 [0.6]	0.26 [2.12*]	0.02 [0.31]

1	2	3	4	5
VAT	0.29 [6.77**]	0.30 [6.49**]	0.19 [1.66]	0.29 [6.41**]
IT	0.04 [0.94]	0.03 [0.76]	0.25 [1.71]	0.01 [0.26]
WA	–0.06 [–0.32]	–0.07 [–0.36]	–0.18 [–0.76]	0.11 [0.76]
WE	0.04 [0.51]	0.09 [1.32]	–0.27 [–1.50]	0.10 [1.26]
WI	0.05 [1.55]	0.04 [1.05]	**0.48 [3.26**]**	0.004 [0.08]
WVAT	0.12 [0.86]	0.10 [0.70]	0.25 [1.63]	0.17 [0.98]
WIT	0.27 [5.63]	0.28 [5.18]	0.21 [2.25]	0.26 [5.41]
P	0.34 [2.84**]	0.24 [1.80]	0.49 [3.79**]	0.11 [0.90]
R^2 (overall)	0.660	0.655	0.678	0.610
Log-pseudolikelihood	–143.24	–73.37	–250.06	–66.56
χ^2	20.94**			

***p < 0.01, *0.01 ≤ p < 0.05*

The outcomes of the Hausman test represents a significant value of chi-squared (χ^2) at p-value less than 1%. Hence, the null hypothesis about the random effect is not supported. Meanwhile, SDM with the time-fixed effects shows the highest overall coefficient of determination (R-squared) of 0.678 and the log-pseudolikelihood of –250.06. Also, results for this model demonstrates a significant spatial interaction between the implementation and export in Ukrainian regions. However, the effect of spatially lagged technology and innovation activity (*A*) as well as expenditure (*E*) are statistically insignificant. Further, the Table 5 represents outcomes for the SAR with random and fixed effects.

Table 5. SAR (Predicted Variable = *Export*)

	Random-effects	**Spatial fixed-effects**	**Time fixed-effects**	**Spatial-time fixed-effects**
1	2	3	4	5
Constant	1.48 [2.10*]	–	–	–
A_{in}	0.08 [0.98]	0.07 [0.84]	0.25 [1.38]	0.19 [1.28]
E_{in}	0.29 [6.77**]	0.30 [6.49**]	0.19 [1.66]	0.29 [6.41**]
I_{in}	0.04 [0.94]	0.03 [0.76]	0.25 [1.71]	0.01 [0.26]

1	2	3	4	5
VAT	0.29 [6.77**]	0.30 [6.49**]	0.19 [1.66]	0.29 [6.41**]
IT	0.04 [0.94]	0.03 [0.76]	0.25 [1.71]	0.01 [0.26]
P	**0.41 [4.31**]**	0.38 [3.40**]	**0.50 [5.26**]**	0.29 [1.99*]
R^2 (overall)	0.645	0.644	0.676	0.618
Log-likelihood	–145.24	–76.71	–263.05	–70.27
χ^2	6.84			

$^{**}p < 0.01$, $^{*}0.01 \le p < 0.05$

Based on the findings, the null hypothesis about the random-effects model is appropriate since the value of chi-squared is insignificant in the context of the SLM. In regards to the random-effects SLM, its coefficient of the determination equals to 0.645 indicating the extent of the variance of the predicted variable which can be explained by the impact of explanatory variables. However, the highest coefficient of determination is identified for the time-fixed effects model which is able to explain more cases (67.6%) than other models. Herewith, the significant value of ρ is determined for both random and fixed-effects models.

The Table 6 illustrates outcomes for the random-effects and three dimensions of the fixed-effects SEM including spatial, time and spatial-time. Since the p-value of chi-squared exceeds 1%, the null hypothesis about the relevance of the random effect cannot be rejected. The random-effects SEM covers 64.3% of cases. However, the time fixed-effects model demonstrates the highest R-squared fitting 65.6% of cases. Also, the significant value of λ identifies the spatial dependence in the models error term within both random-effects and time fixed-effects SEM.

Table 6. – SEM (Predicted Variable = P_{in})

	Random-effects	**Spatial fixed-effects**	**Time fixed-effects**	**Spatial-time fixed-effects**
1	2	3	4	5
Constant	3.83 [4.18**]	–	–	–
A_{in}	0.08 [0.78]	0.09 [0.76]	0.26 [1.61]	0.24 [1.67]
E_{in}	0.42 [6.18*]	0.41 [5.67**]	0.37 [3.61**]	0.37 [6.79**]
I_{in}	0.04 [0.93]	0.03 [0.72]	0.16 [1.19]	0.01 [0.21]
VAT	0.29 [6.77**]	0.30 [6.49**]	0.19 [1.66]	0.29 [6.41**]
IT	0.04 [0.94]	0.03 [0.76]	0.25 [1.71]	0.01 [0.26]
λ	**0.15 [0.67*]**	0.19 [0.76]	**0.60 [3.95**]**	0.02 [0.14]

1	2	3	4	5
R^2 (overall)	0.643	0.639	0.656	0.613
Log-likelihood	–161.81	–90.42	–265.48	–78.45
χ^2	4.67			

***p < 0.01, *0.01 ≤ p < 0.05*

4.3. Policy Impact Evaluation

The policy impact evaluation is conducted by the DID technique which assesses the treatment effect of the policy comparing two periods before and after its implementation. Herewith, we control for two periods evaluating the year of 2019 as a starting point and the year of 2020 as the ending point. Thus, we estimate POM, ATE and ATET. The results of generating the regression PPML model adjusted with the treatment effect are presented at the Table 7 below.

Based on the results, the potential-outcome mean for the export before the policy implementation is smaller comparing to the time period after the policy implementation. Although, the policy on the light industry development is proclaimed, the difference between tax and tax-free result is about 3210.33 thousand dollars per region. Since the value of ATET provides more reliable result, it is still about 2180.5 thousand dollars per region. Therefore, these results prove that the policy on the poverty reduction in Ukraine might be not effective.

Table 7. – Treatment Effect Estimation

Indicator	Full sample
POM: Tax	28330.56 [25.82**]
Tax-free	31540.89 [21.63**]
ATE	3210.33 [4.28**]
ATET	2180.5 [3.30**]

***p < 0.01, *0.01 ≤ p < 0.05*

5. Discussion

The regional expenditure on technology and innovation is linearly and positively related to the light industry's export. These findings suggest a role of the expenditure in promoting the export. Then, the higher level of implementation of R&D and innovation positively associates with the higher volume of the light industry's export. Hence, the higher volume of the innovation products (goods, services) sold by an enterprise implemented innovations contributes to the export activity of the light industry. On the other hand, there is no evidence of the direct linear relationship between the technology and innovation activity and the light industry export. Thus, the export activity is not stimulated by the number of employees engaged in R&D per enterprise in the context of the Ukrainian light industry.

Next, regarding the spatial analysis the null hypothesis about the relevance of the random-effects model is supported in most calculations excepting the SDM. Additionally, the time fixed-effects models demonstrate the highest coefficients of determination within the study comparing to other model specifications. Meanwhile, the best model fitting the data is the time fixed-effects SDM which is able to explain the sample by 67.8%.

Then, in terms of the technology and innovation activity and the expenditure on R&D and innovation, their spatial impacts on the light industry's export are not identified. Thus, these values are distributed randomly across the Ukrainian regions and the export in the particular region is not associated with their values in the neighboring regions. However, the Hypothesis 1 is supported partly, since the values of the implementation of R&D and innovation might influence (or to be related to) the value of the light industry's export in a neighboring region within the time fixed effects. Also, the spatial dependence of the light industry's export is diagnosed in the context of the Ukrainian regions and validated by both random and fixed effects. Finally, within the random and time fixed effects the spatial dependence in residual terms among neighboring Ukrainian regions is detected supporting the assumption that the residuals might affect (or to be related to) residuals in a neighboring area. Namely, the model captures impact of other unmeasured explanatory values.

Therefore, the results of this research support the idea of the unified policy regarding the digitalization and innovative transformations of the Ukrainian light industry announced by the government. However, it might focus not only on maintaining sustainable development of the light industry in the leading regions, but also promoting it across all Ukrainian regions. Further, a multi-scale spatial cooperation process is required to be implemented based on both geographical background and technological advancement of the Ukrainian regions.

6. Conclusion

The research attempts to verify the justification of the centralized policy on the digitalization and innovative transformations of the Ukrainian light industry proclaimed by the government. The empirical data involves the regional indicators of the technological and innovative development and the light industry's export of 27 Ukrainian regions from 2012. The indicators of technological development involve the regional technological and innovative activity, expenditure on R&D and innovation and the innovation implementation. The research methodology includes: 1) the regression analysis to investigate the linear relationship; 2) the spatial analysis to test the spatial interactions; 3) the Hausman test to verify the consistency of the random effect; 4) DiD technique to verify difference before and after policy implementation.

The research results demonstrate: 1) a positive linear effects of the regional expenditure and R&D implementation on the light industry's export; 2) a spatial relationship between implementation and export within time-fixed effect; 3) the spatial dependence of the light industry's export and in residuals within random-effects models; 4) the positive effect of the policy implementation.

The scope of the research concerns the Ukrainian regions and the light industry. It does not involve other regions or industries. Besides, the data referring Crimea and Sevastopol is not employed by the research since the data is not available.

The further research might include other regions and industries in order to compare the results with the outcomes of the current study. Then, other factors can be added to the research model such as GRP, educational level, labor cost and others.

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