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KOTRYNA STANKAITYTĖ, 3rd year student of Quantitative Economics

(STUDENT'S NAME AND SURNAME IN CAPITAL LETTERS)

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Student _____

(signature)

Supervisor PhD, prof. Povilas Lastauskas

(scientific degree of the supervisor, academic
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INTRODUCTION

Recent year showed new challenges to face with emerge of COVID-19 virus. It directly affected almost all areas worldwide for households, businesses, and governments. Each was forced to adjust its operation under new circumstances and challenges. Households had to switch to remote lifestyle limiting time outside their houses. Part of businesses was forced to close down, and those who did not faced these restrictions had to change to remote work. Government was left to deal with situation and consequences afterward under pressure for facing a threat that was not faced in a long time.

Due to virus spreading through space, spatial analysis of its impact is applicable. This kind of analysis is used to investigate patterns of variables throughout the space. Within spatial analysis, one of the most popular topics in statistical analysis are diseases rates, hazard incidents and elections. Spatial analysis finds degree of spatial dependence in analysed data.

The main purpose of my thesis is to analyse how, and which industries were affected during COVID-19 outbreak. For empirical part I performed quantitative panel data analysis of 24 European Union countries (Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden) during the period of 2020-03 to 2021-03 and investigating what affect was found for industrial production index, divided into 8 groups – capital goods, durable consumer goods, non - durable consumer goods, energy, high technology, low technology, medium - low technology, intermediate goods. In analysis I use fixed effect regression with clustered errors for small sample. In addition, regression with fixed effect time trend and clustered errors is presented for comparison of the results. The main spatial analysis is conducted following time trend regression and overall results are compared.

After conducting the analysis, it is found that panel data analysis and spatial analysis showed rather different results. Number of new cases in panel regression analysis showed positive effect, while spatial analysis showed negative effect. Human development index was omitted form panel analysis and stayed in spatial analysis showing bot positive and negative effects depending on the industry analysed. Consumer price index and unemployment showed similar signs during both analyses, however significant values were achieved with spatial analysis. Stringency index showed significant and negative effect during panel analysis, however with spatial analysis it lost significance and presented both positive and negative effects.

This paper is organized as follow. In Section 1.2 background of COVID-19 and the main policies applied by the countries to restrain the spread of virus are provided. Section 1.3 analyses scientific literature in detail, presenting main methods, assumptions, and results. Section 2.1 contains of data description and explanation. Section 2.2 provides descriptive data statistics of variables that were used. Section 2.3 explains the methodology and models that were used. Section 3 provides review of empirical research results and main findings of the paper. Conclusions and recommendation section provides main information and findings of the paper and recommendations regarding long – run goals in constraining COVID-19. Reference parts provided literature and data that was used while writing this paper. Last parts contain of summary of the paper in English and Lithuanian.

1.THEORY AND SCIENTIFIC LITERATURE

1.1 Theory

Jean Paelinck in 1974 introduced term of spatial econometrics in the annual meeting at the Dutch Statistical Association and further analysed the field and spatial regression models for cross – sectional and panel data (Paelinck, Klaassen, 1979). Model of interest were the ones, showing spatial autocorrelation. (Anselin, 1998) expanded the research and the depth of the context. Spatial economic analysis is relatively new subject and is gaining popularity in various researches.

One of the reasons for growing popularity of spatial analysis, is the need of models in econometrics, that provide clear results of economic agent interacting with another exogenous agent in economy. (Anselin, 2001) Spatial analysis provide clear effects of agents or groups interactions with the impact of additional variables. It helps to see the impacts if only one agent adapts certain policy or starts individual interaction, and what results it has in its neighbours. If the dependency is found, this proves spatial autocorrelation existence. Another reason is the need of models to analyse spatial data. With the increase of geographic information systems (GIS) the amount of spatial data increased, and standard econometric models failed to recognise spatial autocorrelations in cross – sectional data. Spatial effects fall into two main groups – spatial autocorrelation that accounts for special dependencies and spatial heterogeneity that accounts for heteroskedasticity in error term. While spatial heterogeneity can be controlled by simple econometric tools, same tools usually fail to detect spatial autocorrelation. To detect spatial autocorrelation, one of two main models are applied – it can be spatial lag autoregressive model (SAR) for cross – sectional data or spatial moving average model (SMA) for panel data. For model estimation three main estimation methods are used – maximum likelihood (ML) that assumes normality of the error term, spatial two – stage least square (2SLS) that uses mean of instrumental variables to address endogeneity of the spatially lagged dependant variables in the model and finally generalizes method of moments (GMM) that estimates spatial error autocorrelation.

Spatial analysis is a broad topic that can apply or augment many tools used in the econometrics. The main idea is intuitive and easy to understand. It provides the understanding of importance of neighbour's actions. With spatial analysis it is possible to analyse how firms wait for reaction from competitor and only then reacts. Additionally, during the period of crisis it is possible to analyse if the risk and severity can be shared among the countries and if the situation in country affected its neighbours.

1.2 Background

COVID-19 virus caused disruption worldwide by causing massive lockdowns that affected every aspect of life. As virus appeared to be spreading easily, countries adopted many different policies to control the spread of COVID-19. It started in 2019 December in China, Wuhan city. Since then, countries around the world had started quarantines, applied many restrictions to business to avoid high mortality and many times at cost of economic performance.

In history, this is not the first-time world is facing a threat of a virus. In 1918 – 1919 global influenza killed 40 million people. However, reproduction rate at that time was lower and differently than now, not whole population had to face a disease, while with COVID-19 the spread is much higher and faster due to increase in the people mobility. More recent outbreak was Ebola virus outbreak in Africa during 2013 – 2016 that was estimated that economic costed 14\$ billion (Huber, Finelli, Stevens, 2016). However, this outbreak is different, as its measure is worldwide and all countries faced issues regarding COVID-19. Differently than with Ebola virus, it is not focused on low – middle income countries. As countries around the world try to diminish the costs of controlling the spread of virus, each country accepts the best policies for its country, in this way disrupting even more demand and supply.

Policies applied by countries in EU were similar and in general can be divided in 6 main groups – foreign travel restrictions, internal travel restrictions, school closure, service sector closure, limited mass gathering and state of emergency. These policies applied are meant to decrease the spread of virus among people. Throughout the analysed time frame 2 waves of COVID-19 appeared, and between the waves many of restrictions were released with hopes for economy to recharge before the second wave.

Governments also applied monetary and fiscal policies to help business to avoid bankruptcy as long as possible. Czechia, Romania, and Poland adopted new monetary policies to mitigate negative impact of COVID-19 and issued new government bonds. In addition to that, Czechia increased FX swap stock. Hungary expanded grace period for firm's loans under FSG scheme. Lithuania expanded the deadline to update KYC information for financial institutions and Bank of Lithuania issued aid package that provided additional longer-term refinancing operations for bank to lend more easily. It also released conditions for targeted longer-term refinancing operations for households and non – financial institutions to get a loan. To keep the stability, Bank of Lithuania also increased public sector purchase programme, when European Central Bank Governing Council decided to extend restrictions if it is needed. Bank of Sweden agreed to keep repo rate at zero until 2023 and increased public budget. Government of Sweden decreased their growth forecast for 2021. Austria applied number of different policies, including lowering

personal income taxes to 20%, engaging local government investment programs to various sectors to stimulate economy, assuring guarantees from Austrian COVID-19 funding agency and increasing expenditures to fund households and business that lost sales because of COVID-19. In addition to that, ECB started emergency fund for EU countries to purchase bonds if it is necessary that summed to the spending of 750 billion Euros and Bank of France and central bank of Italy used this opportunity.

One way to control the spread of COVID-19 was to use a broad federal fiscal package to stimulate certain industries that after analysing seem to be at highest risk and once situation is controlled, switch to another industry. Alongside in debating the proportions for importance whether it is more important to save economy or decrease the mortality, governments were left to debate and argue between different parties decreasing business trust. It is certain, that government that keep switching policies and is not holding on it consistently in the long – run will face higher decrease in economic indicators than countries, that keep adapted policies and kept working consistently. However, certain policies adapted, like social distancing, stay at home or regulation of maximum number of people outside or inside, most definitely severely damaged income sources for small and medium business in service sector and fault fell on the government as it failed to help medium and small business when their applied policies closed income sources.

1.3 Analysis of scientific literature

After more than a year of trying to take COVID-19 under control, countries are still facing increasing number of cases. Different countries tested various policies to control the virus and prepare for the second wave while not being able to reduce infection rates to minimum. Disease is transmitted to human – to – human and is spreading rapidly in inner communities, where safety rules are violated. Countries had time to prepare new directories to prevent the spreading of the virus and after the first wave, collaborative strategies were adopted, including closure of the country's boards. Decisions are made based on the research and data. COVID-19 outbreak is exceptional because it caused worldwide crisis. Papers that are analysed can be divided into two groups – first groups of papers analyse industrial growth during crisis and second group analyses spatial patterns during COVID-19.

First group of papers provides deeper insight on industrial growth during crisis and economical performances during various crisis. Financial crisis impact on industry growth is analysed by Moroe and Mirzaei (2014). Authors analysed industry growth across 82 countries in 23 industries and

researched what is the main mechanism that creates financial crisis in the real sector. The main findings showed that because of heterogeneity across the countries almost all researched countries faced a high decrease in performance. Low and lower income countries were less affected by the crisis than the higher income countries. Model in the research used panel data, estimated on heterogenous effects and applied sensitivity test. Overall countries that rely more on external finance dealt with more severe recession. The model used in the paper was used in this paper and augmented to include different variables and adjusted to COVID-19 situation. Fernandes (2020) analysed spillover effect during COVID-19 outbreak in world. Author discusses, that based on historical data during crisis countries are able to share risk, this time it is not likely to be the case, as all countries suffer from COVID-19. Data analysis, of 30 countries high frequently data, showed that additional month of shutdown on average will decline 2.5 – 3% of global GDP. Spillover effect is also analysed by Ozili and Arun (2020). Authors investigate spillover effects of COVID-19 on the global economy and find that by applying many different policies, mostly to restrain the spread of virus, it also restrained economic performance and had a negative impact. Authors analyse 17 different countries in the World to see how economic activities and stock market indices were affected by the adopted monetary policy measures, fiscal policy measures, lockdowns, and international travelling restrictions. It is found that applied policies had a negative impact on economic factors and stock market indices. Interesting find in the paper was that with internal movement restrictions and higher fiscal policy spending, impact on economic activities appeared to be positive and COVID-19 cases in country did not had a significant effect. Similarly, to Fernandes authors emphasize that countries success in constraining COVID-19 depends on the policies, applied in the country and not in region. However, this point of view can be short – looking and in analysis, conducted in the future may show to be incorrect. Both papers, differently than Moroe, Mirzaei (2014) concludes that during crisis countries are not sharing risk and dividing it among. Enu, Hagan and Attah – Obeng (2013) analysed panel data from 1990 to 2010 of Ghana, with OLS estimation to find impact of macroeconomics factors on industrial production growth. Authors used Cobb – Douglas production function to determine best variables to use in regression. They also used several tests to accompany their analysis and test for multicollinearity, autocorrelation, heteroscedasticity and robustness of the model. It is found that industrial production is influenced positively by government spending and import of goods and services, while negative impact is created by real exchange rates and real petroleum prices. Authors later draws conclusions on the main policies that should be applied to ensure industrial production growth. Importance of policies applied during crisis, more precisely during COVID-19 are discussed by Ambrocio (2020). Author analysed business

confidence in Euro Area during COVID-19 and used cross – sectional data of 11 countries. The main variable of analysis was industrial production growth that was analysed in short – term using 2020 year data. Instrumental variable analysis was used when household confidence was used as an instrument for the business confidence, and it showed a decrease in the industrial production growth and wholesale retail trade sector. Policies, applied by the government were relevant to the analysis and showed significance impacting confidence and expectations. With weak government responses countries confidence levels were lower. Author discusses that higher and more elaborative policy implication and explanation could be a key to increase confidence. Sornette, Mearns, Schatz, Wu and Darcet (2020) analyse and model COVID-19 mortality data and investigates the relation with stringency index. For analysis, chosen countries are divided in 5 groups: Western countries, East Block, developed Southeast Asian countries, Northern Hemisphere developing countries and Southern Hemisphere countries. When divided into groups, it is easier to get more reliable results, as policies implied are usually similar in the region. Authors find that in Western countries one of the main reasons for a severe COVID-19 epidemic is because high part of population is of elderly people. Authors also find that increase of stringency level in country level decreases number of COVID-19 cases in the short – run. Authors also emphasize a lot, that while dealing with pandemic, people life should be the main priority and even though at the moment it is still unclear of what is the best strategy to manage virus. Prioritised objectives in the paper are: first – protection of the human life, second – keeping casualties at the lowest and last objective is to avoid occurrence of subsequent economic damage. Overall papers analyse, that policies applied during crisis are the key source to control it. During every crisis, industrial growth, and economic performance decrease, however the severity depends on whether countries are able to share the consequences and risk among or not. Historical data and previous crisis analysis show, that countries share risk and recent COVID-19 researches conclude that at the moment countries are damaged too severely to share risk between.

Another analysed literature consists of papers that analysed spatial patterns during COVID-19 outbreak. Raymundo, Oliveira, Eleuterio, André, Silv, Queiroz (2021) study analysed panel data of 26 Brazil's states and the Federal District in the period from February 25 to September 26, 2020. For variables that were used authors used Spearman's correlation coefficient to perform criteria of correlation. For spatial dependencies global Moran's index (GMI) and for clusters dependency Local Index of Spatial Association (LISA) were performed. For regression models, OLS, SAR, CAR and MGWR models were used. Results showed that the spread of COVID-19 is positively correlated with GINI index and nurse ratio per 1000 inhabitants, while inverse correlation was found with mortality rate.

Study also showed that as social inequality increases the spread of virus, we see that municipalities with higher social development have lower number of cases. It is related to greater access to health services. Spread of COVID-19 impact on mortality rates using small time sample is also discussed by Shobande, Ogbeifun (2020). This study analyses spread of COVID-19 impact on mortality rates for 79 countries in 6 continents. Countries in each continent were chosen based on the number of COVID-19 cumulative confirmed cases (CCC) differentiating for the continents. For Australia and Oceania countries with CCC of 500 and above, Africa and North America with CCC of 1000 and above, for Europe 10000 and Asia 5000 of CCC. Time frame chosen for this paper is last year data. Paper investigates spatial pattern in control for COVID-19 outbreak for population health with potential threat of endogeneity and draws conclusions on how to reduce the spread of virus and control for possible occurrences in the future. Study examines spatial variations of COVID-19 on mortality using System Generalized Method of Moments (SGMM) and resulted in evidence of spatial variation between COVID-19 and mortality rates to be positive and significant. Strategies to control the spread depend on geographical location and public health framework. Social tension caused by COVID-19 outbreak is positively correlated with daily mortality outcome. This paper confirms that human development is important variable in the analysis as it reflects successfulness of health sector operation. Adekunle, Onanuga, Akinola, and Ogunbanjo (2020) investigates 52 African states that at the time of writing had reported 10787 confirmed cases with 501 death. Authors chose to investigate mortality outcome for COVID-19 in Africa is based on fact, that virus is transmitted human-by-human and Africa is overcrowded, therefore even encouragement of social distancing might be unaffordable as there might be no place to keep distance in overcrowded places and residences. and it should result in high numbers of COVID-19 cases in the states. This study uses panel data of confirmed and death cases and later estimates Generalized Method of Moments (GMM) to account for cross – sectional dependency. Empirical analysis resulted in providing that confirmed cases of COVID 19 have strong positive and significant relationship with death rate in Algeria and mixed results for other regions. Overall spatial and statistical evidence of linear relationship between confirmed cases and deaths was found. Another spatial analysis field was adapted to analyse policy applications and exogenous variables impact in Bulgaria Dokov, Milkova and Stamenkov (2020). Paper analysis how open economy of Bulgaria created a threat of crisis because of the influence of exogenous factors. As economy is highly dependent on global trends, country faced limited solutions to avoid deep crisis. Altogether, Bulgaria at the time was facing nearly two months of anti-government protests, that added to already coupling medical and economic crisis in the country. Study concluded, that because of existing spatial correlation between the spread of COVID-19 and Bulgaria economy, depending on political

responses, local economies specialization, social, demographic structure, and integration of local economies to global supply chains. Analysis showed asymmetrical impact of COVID-19 to territories, raising a discussion on the importance of political, economic, financial, and demographic variable importance, which was not addressed empirically in the study. Authors suggest that strong horizontal and vertical mechanism between government structures would improve situation and decrease possible costs due to asymmetric information and incorrect policies applied.

Table 1

Summary of scientific literature

Authors	Countries/areas	Time Frame	Methods and models	Main findings
Moroe and Mirzaei	82 countries	2000 – 2010	Panel data, empirical results based on heterogenous effects, also applying sensitivity test.	Low and lower than middle income countries were less affected by the crisis, however all industries faced decline in performance.
Fernandes	30 countries	2019 - 2020	High – frequently data, estimated and then forecasted.	Depth and length of recession depends on measures to prevent the spread of COVID, government policies and business reaction to re-start economic activities.

Continuation of Table 1

Ozili, Arun	17 countries worldwide	2020	Panel data analysis.	Social distancing and lockdown recession had a strong negative impact on economy.
Ozili, Arun	17 countries worldwide	2020	Panel data analysis.	Social distancing and lockdown recession had a strong negative impact on economy.
Enu, Hagan, Attah – Obeng	Ghana	1990 - 2010	Panel data, OLS analysis	Industrial production is impacted by real petroleum prices, real exchange rate, import of goods and services and government spending.
Ambrocio	11 Euro area countries	2020	Cross – country panel data. OLS and IV estimations.	Confidence and expectations highly affected economic transmission of COVID-19
Sornette, Mearns, Schatz, Wu, Darcet	Worldwide countries	2020	Panel data, GLM method.	In short – run increase of stringency index decreases death count.

Continuation of Table 1

Raymundo, Oliveira, Eleuterio, André, da Silva, Queiroz, et al.	Brazil, 26 states, 5570 municipalities.	2020	SAR, CAR and MGWR models, OLS estimation	At the municipal level, GINI index and nurse ratio is positively correlated with higher spread of COVID. Mortality ratio is inversely correlated with spread of virus.
Shobande, Ogbeifun	79 countries in six continents	2020	Spatial panel data, empirical results are based on fixed effects (FE) and System Generalizes Method of Moments (SGMM)	Spread of COVID has a significant and positive relationship with mortality. Social tension is positively correlated with daily mortality outcome
Adekunle, Onanuga, Akinola, and Ogunbanjo	52 Africa states	2020	Panel data, estimation with fixed effects and Generalized Method of Moments (GGM)	Confirmed cases of COVID have strong positive and significant relationship with death rate in Algeria and mixed results for other regions.

Continuation of Table 1

Dokov, Milkova, Stamenkov	Bulgaria	2020	Spatial data at NUT – 3 level	Cauterization among the Balkan countries could be instrument for the stability of the region.
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Compiled by the author based on the sources listed in the table.

To summarize literature, analysis conducted on previous crisis claimed, that industrial growth and other economic variables decreased, however risk was shared among countries to minimize the effects. Researches conducted during COVID-19 claim that sharing risk will not be able this time, and countries individually will face more severe crisis. Literature on spatial analysis provided results, that policies applied during COVID-19 have a strong negative impact on the economic variables and industry growth. Spatial patterns were found in between mortality and new cases.

2. DATA AND METHODOLOGY

This part of the paper consists the technical side, describing used data, descriptive statistics and the model that is used for analysis.

2.1 Data

For the quantitative analysis of spatial COVID-19 effects on economy in European Union countries I used cross-sectional panel data. Data was acquired from two online sources. One of them is Eurostat (European Statistical Office). Another data source is European Centre for Disease Prevention and Control, that is an agency of the European Union. The selected period of time was from 2020 – 02 to 2021 – 03 for 24 countries in EU. This data frame is selected based on the beginning of COVID-19 spread around the globe.

The variables for analysis were chosen based on models provided in scientific literature. Dependant variables are industrial production index, for main industrial groupings aggregated with technology industries:

- Durable consumer goods, monthly data, index 2015 = 100, seasonally and calendar adjusted.
- Non – durable consumer goods, monthly data, index 2015 = 100, seasonally and calendar adjusted.
- Energy, monthly data, index 2015 = 100, seasonally and calendar adjusted.
- Capital goods, monthly data, index 2015 = 100, seasonally and calendar adjusted.
- Consumer goods, monthly data, index 2015 = 100, seasonally and calendar adjusted.
- Intermediate goods, monthly data, index 2015 = 100, seasonally and calendar adjusted.
- High technology, monthly data, index 2015 = 100, seasonally and calendar adjusted.
- Medium – Low technology, monthly data, index 2015 = 100, seasonally and calendar adjusted.
- Low technology, monthly data, index 2015 = 100, seasonally and calendar adjusted.

Independent variables for analysis were chosen as follow:

- Consumer price index, monthly data, for 24 EU union country.
- Unemployment, monthly data, for 24 EU union country.
- New Cases, monthly data, for 24 EU union country.

- Stringency index, monthly data, for 24 EU union country.
- Human development index, monthly data, for 24 EU union country.

Consumer price index was chosen to reflect overall change in prices for households for purchasing consumer goods and services. Consumer price index also is main indicator of inflation. Increase in inflation created uncertainty which leads to lower rates of growth in the economy. Unemployment variable measures proportion of actively work searching people over percentage of active population. When workers are unable to find workplace, economic output accordingly decreases, and high or low unemployment rates are a signal of economic distress. The variable was not divided by the industries analysed and is used as general for each country. New cases variable measures a number of new COVID-19 cases per month in each country. Increase of new cases in country lead to implementation of stricter policies in country that as result constrains economy. Stringency index is a composite measure based on nine main policy response indicators on country level regarding COVID-19 situation. When number of COVID-19 cases increase, government implement new policies to control as a result. Human development index measures average achievement in three dimensions at country level – health, knowledge, and GINI index. An average of these dimensions creates human development index, which is used to control for the difference, created by implemented national policies for countries, that share similar GINI index.

2.2 Descriptive statistics

Below in the Table 2 descriptive statistics are presented of the variables that were used in the analysis. Each variable presented 288 observations for 24 European Union countries. It is visible, that some variables provide high standard deviation, while other have smaller standard deviation. To control for possible errors, during the analysis all variables are under logarithmic function to decrease variations. Not mentioned in the Table 2, however used is GIS data, collected at NUTS – 1 level and later filtered to contain only European Union countries that have at least one neighbours with continental board. This way all the islands were excluded.

Table 2*Descriptive statistics of data*

Variable	Obs	Mean	Standard deviation	Minimum	Maximum
Consumer Price Index	288	106.9241	3.266132	99.20	115.94
Unemployment	288	7.007634	3.259907	1.9	17.3
New Cases	288	77393.26	152149.7	55	922124
Stringency Index	288	58.20897	15.16534	24.94194	95.43467
Human Development Index	288	0.8949167	0.0368096	0.816	0.947
Capital Goods	288	107.949	25.91961	40.6	199.1
Intermediate Goods	288	107.6708	15.83794	54	174.2
Durable Consumer Goods	288	105.1808	25.19455	13	166.4
Non – Durable Consumer Goods	288	104.3587	NA	73.3	155.3
Energy	288	94.97246	14.39815	58.7	133.2
High Technology	288	124.9217	29.6837	75.6	245.3
Medium – Low Technology	288	107.8492	19.52511	67	166.7
Low Technology	288	103.3	8.90658	84.7	124

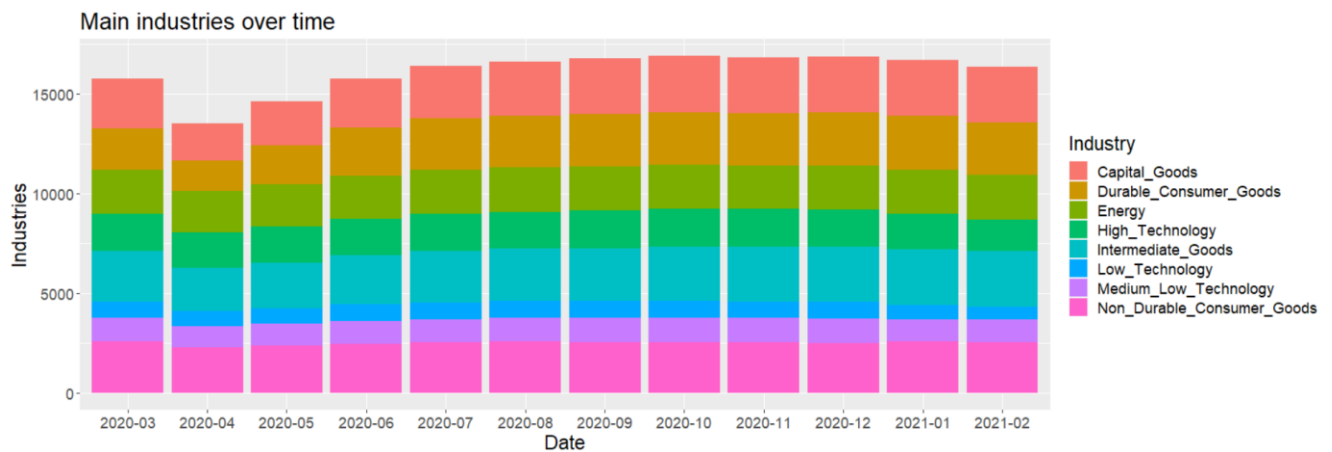
Source: compiled by the author using Eurostat data

Figure 1 below represent industrial production index for 8 industries over analysed time period in all analysed countries. It is visible, that in April of 2020 all industries except for non – durable consumer goods, suffered a decrease in the production. It is understandable that decrease started in April as first stricter policies were applied in March and their affect was visible in the next month. Non –

durable consumer good show the lowest changes over time therefore it is expected that variables during empirical analysis should not affect this industry much. High and significant effects are expected to be find in capital goods, intermediate goods, durable consumer goods, energy, and high technology industries. Low technology and medium – low technology industries show swinging, however it is not clear if affects will be significant after analysis. Another visible decrease can be seen in the last month, most likely portraying second wave of COVID-19, however the decrease is visibly lower, giving hope, that countries and businesses were more prepared for new lockdown.

Figure 1

Industrial production index



Source: compiled by the author using Eurostat data

2.3 Method

To test COVID-19 impact on industries, I investigate relationship between industrial production index and COVID-19. Following estimation model is based on Moore and Mirzaei (2014) and extended

$$\log (IndustryGrowth_{ict}) = \beta_0 + \beta_1 \log (ConsumerPrice) + \beta_2 \log (Unemployment) + \beta_3 \log (NewCases) + \beta_4 \log (StringencyIndex) + \beta_5 \log (Human_Development_Index) + \varepsilon_{it} \quad (1)$$

Dependent variable is industrial production index, that measures monthly changes of price - adjusted output of industry i in countries c at time t . Industries that I am analysing are capital goods,

durable consumer goods, non – durable consumer goods, energy, high technology, low technology, medium low – technology, intermediate goods. To account for COVID-19 effects, variables indicating consumer prices index, unemployment, stringency, and human development index are used. All variables are under logarithmic transformation to improve the fit of the model by making features of distribution more normally – shaped.

For linear regression fixed effect estimation was chosen as for majority of industries Hausman test showed exogenous regressors. Fixed effect estimation controls for country and year as data varies in space and time. Standard error was clustered by country with small sample correction. Hausman test was conducted to test whether random effect or fixed effect should be used, and final regression and overall result indicated that fixed effect is more suitable for this regression.

Spatial analysis was conducted using cross – sectional data and regressing spatial autoregressive lag (SAR) and spatial Durbin model with Maximum likelihood estimation and row – standardised spatial weights matrix. SAR model allows dependant variable to depend on observations in neighbouring areas and spatial weight matrix in the model refers to additional variable in the model, that adds spatially lagged dependant variable. Fischer, Wang (2011) To test for spatial dependence, spatial Durbin model (SDM) is used. SDM model provides unbiased estimator that omits spatially auto – correlated errors. For estimation, maximum likelihood estimation (Ord, 1975) was used.

3. REVIEW OF RESEARCH RESULTS

Fixed effect analysis omits human development index from analysis due to multicollinearity. Results in the Table 3 show that consumer price index is significant only for capital goods industry during this period of time and positively affects this industry at 0.01 significance. Also, it is significant at 0.1 for low technology industry. Unemployment significantly and positively affects capital goods, energy, durable consumer goods, non – durable consumer goods, medium – low technology and intermediate industries. New cases variable is significant for all groups of industries, except for energy industry and positively increases all industries. Stringency index is significant to all industries and has negative influence on it, and for energy industry it has the lowest impact.

Table 3

Results of regression with fixed effects

	<i>Dependent variable:</i>							
	log(Capital_Goods)	log(Energy)	log(Durable_Consumer_Goods)	log(Non_Durable_Consumer_Goods)	log(High_Technology)	log(Low_Technology)	log(Medium_Low_Technology)	log(Intermediate_Goods)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(Consumer_price_index)	4.948*** (1.613)	-0.116 (0.712)	-1.452 (2.354)	-0.673 (0.573)	0.395 (1.127)	2.179** (0.904)	0.424 (1.029)	0.548 (0.898)
log(Unemployment)	0.338*** (0.095)	0.142*** (0.043)	0.885*** (0.137)	0.080** (0.034)	0.063 (0.058)	0.027 (0.039)	0.125** (0.054)	0.193*** (0.053)
log(New_Cases)	0.046*** (0.005)	-0.0001 (0.002)	0.051*** (0.007)	0.008*** (0.002)	0.011*** (0.003)	0.013*** (0.002)	0.022*** (0.003)	0.032*** (0.003)
log(Stringency_Index)	-0.281*** (0.035)	-0.033** (0.015)	-0.445*** (0.051)	-0.106*** (0.012)	-0.089*** (0.025)	-0.099*** (0.015)	-0.123*** (0.024)	-0.131*** (0.019)
Observations	262	252	251	262	162	86	121	262
R ²	0.419	0.072	0.436	0.291	0.150	0.519	0.417	0.438
Adjusted R ²	0.352	-0.036	0.371	0.210	0.044	0.447	0.340	0.373
F Statistic	42.176*** (df = 4; 234)	4.340*** (df = 4; 225)	43.335*** (df = 4; 224)	24.068*** (df = 4; 234)	6.332*** (df = 4; 143)	19.925*** (df = 4; 74)	18.933*** (df = 4; 106)	45.615*** (df = 4; 234)

Note:

*p<0.1; **p<0.05; ***p<0.01

Source: compiled by the author using Eurostat data.

In table 4, standard errors were clustered by countries as variables vary through space and are most likely correlated. Consumer price index loses significance of 0.01, however it is still significant and positively impact capital goods. Unemployment is significantly positively affecting four industries – capital goods, energy, consumer goods and intermediated goods. New cases per month is significantly and positively affecting all industries except for the energy, like it was before clustering standard errors. Stringency index is negatively affecting all the industries.

Table 4***Results of clustered errors for regression***

	<i>Dependent variable:</i>							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(Consumer_price_index)	4.948 [*] (2.589)	-0.116 (1.137)	-1.452 (4.032)	-0.673 (0.850)	0.395 (1.223)	2.179 (1.787)	0.424 (1.402)	0.548 (1.647)
log(Unemployment)	0.338 ^{**} (0.153)	0.142 [*] (0.074)	0.885 ^{***} (0.332)	0.080 (0.067)	0.063 (0.056)	0.027 (0.048)	0.125 (0.105)	0.193 [*] (0.114)
log(New_Cases)	0.046 ^{***} (0.007)	-0.0001 (0.003)	0.051 ^{***} (0.006)	0.008 ^{***} (0.002)	0.011 ^{**} (0.005)	0.013 ^{***} (0.004)	0.022 ^{***} (0.005)	0.032 ^{***} (0.004)
log(Stringency_Index)	-0.281 ^{***} (0.054)	-0.033 ^{***} (0.012)	-0.445 ^{***} (0.052)	-0.106 ^{***} (0.014)	-0.089 ^{***} (0.032)	-0.099 ^{***} (0.021)	-0.123 ^{***} (0.030)	-0.131 ^{***} (0.024)

Note:

* p<0.1; ** p<0.05; *** p<0.01

Source: compiled by the author.

Consumer price index positively affects capital goods industry. As capital goods industry creates material for further production of the products. As consumer price index is the main measure of the inflation, increase in the prices of a consumed basket of goods increases capital goods industry that is directly related with the production.

Unemployment positively affects four of the industries – durable consumer goods with highest significance, capital goods, with significance of p – value of 0.05 and energy and intermediate goods with p – value of 0.1. As unemployment during COVID-19 emergence increased due the increase in strict policies that constrained the operation of certain business, especially service industry, many of workers that were laid down received high social benefits that might have increased the consumption of durable consumer goods, because on average, people tend not to act rational during crisis that affect their financial stability (Kapounek, Korab, Deltuvaite, 2015). As unemployment provided positive and significant impact, it can be also discussed that unemployment is endogenous in this analysis, as unemployment variable is not divided in each of the industries and is calculated at country level. This is limitation of this paper and could be discussed in future researches.

New cases have a small positive affect to the industries, except for the industry. It may be explained by the fact, that from the beginning of the quarantine and adaptation to remote work, consumption increased even though many lost their workplaces or were forced to downtime and more social benefits were paid by the governments. However, the impact even though is significant, proves relatively small impact.

Stringency index affects all the industries significantly and has a negative impact. As stringency index measures the hardness of policies applied, the higher index is, the more complicated it is for business to operate as many restrictions are applied.

In the Table 5 below regression with fixed effect time trend and clustered errors is presented for comparison of the results.

Table 5

Results of time trend regression with fixed effects

	<i>Dependent variable:</i>							
	log(Capital_Goods) (1)	log(Energy) (2)	log(Durable_Consumer_Goods) (3)	log(Non_Durable_Consumer_Goods) (4)	log(Intermediate_Goods) (5)	log(High_Technology) (6)	log(Low_Technology) (7)	log(Medium_Low_Technology) (8)
log(Consumer_price_index)	2.878* (1.501)	-0.470 (0.713)	-4.145* (2.122)	-1.049* (0.573)	-0.554 (0.843)	-0.035 (1.141)	2.086** (0.904)	-0.366 (0.986)
log(Unemployment)	0.023 (0.098)	0.072 (0.050)	0.372*** (0.138)	0.023 (0.037)	0.025 (0.055)	-0.013 (0.071)	0.006 (0.043)	-0.007 (0.061)
log(New_Cases)	0.002 (0.008)	-0.009** (0.004)	-0.019* (0.011)	0.0003 (0.003)	0.008* (0.004)	0.002 (0.006)	0.010*** (0.003)	0.007 (0.005)
log(Stringency_Index)	-0.245*** (0.032)	-0.028* (0.015)	-0.382*** (0.046)	-0.100*** (0.012)	-0.112*** (0.018)	-0.082*** (0.025)	-0.093*** (0.016)	-0.113*** (0.022)
time(log(Capital_Goods))	0.032*** (0.005)							
time(log(Energy))		0.006*** (0.002)						
time(log(Durable_Consumer_Goods))			0.051*** (0.007)					
time(log(Non_Durable_Consumer_Goods))				0.006*** (0.002)				
time(log(Intermediate_Goods))					0.017*** (0.003)			
time(log(High_Technology))						0.007* (0.004)		
time(log(Low_Technology))							0.002 (0.002)	
time(log(Medium_Low_Technology))								0.011*** (0.003)
Observations	262	252	251	262	262	162	86	121
R ²	0.519	0.102	0.556	0.323	0.526	0.171	0.528	0.492
Adjusted R ²	0.461	-0.006	0.502	0.242	0.469	0.060	0.450	0.419
F Statistic	50.198*** (df = 5; 233)	5.082*** (df = 5; 224)	55.893*** (df = 5; 223)	22.255*** (df = 5; 233)	51.767*** (df = 5; 233)	5.841*** (df = 5; 142)	16.334*** (df = 5; 73)	20.335*** (df = 5; 105)

Note: *p<0.1; **p<0.05; ***p<0.01

Source: compiled by the author.

Consumer price index provides different impact on different industries – it positively influences capital goods and low technology, while negatively impacts durable and no – durable consumer goods. Unemployment positively significantly influences only durable consumer goods industry. New cases like in the regression before have relatively low values, however now it shows different signs and positively

impacts intermediate goods and low technology, while negatively reacts to energy and durable consumer goods industries. Stringency index provides highly significant negative impact to all industries except for energy, where significance is lowest. To investigate deeper R - squared of energy industry is lowest among all the industries. It is also important to notice, that R – squared is higher for the regression with time trend for all the industries analysed.

Table 6 shows clustered error terms for time trend regression, and it shows that only stringency index keeps the influence on the industrial production index. Only for energy industry significance increases with clustered errors. New cases show still small and not highly significance effect to energy and low technology industries. Consumer price index show negative, however not significant impact on all industries except for low technology. Negative consumer price index value is intuitive and understandable as increase in inflation increases prices for production. Unemployment provided mostly positive, however not significant values. Positive values can be the case of endogeneity as because of COVID-19 unemployment increased and it is directly related to industrial production index, that is dependant variable in the analysis.

Table 6*Results of clustered errors for time trend regression*

	<i>Dependent variable:</i>							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(Consumer_price_index)	2.878 (2.108)	-0.470 (1.101)	-4.145 (3.306)	-1.049 (0.801)	-0.554 (1.356)	-0.035 (1.036)	2.086 (1.789)	-0.366 (1.317)
log(Unemployment)	0.023 (0.154)	0.072 (0.078)	0.372 (0.285)	0.023 (0.059)	0.025 (0.104)	-0.013 (0.062)	0.006 (0.066)	-0.007 (0.085)
log(New_Cases)	0.002 (0.010)	-0.009* (0.005)	-0.019 (0.014)	0.0003 (0.003)	0.008 (0.006)	0.002 (0.006)	0.010** (0.005)	0.007 (0.006)
log(Stringency_Index)	-0.245*** (0.052)	-0.028** (0.012)	-0.382*** (0.048)	-0.100*** (0.013)	-0.112*** (0.024)	-0.082*** (0.031)	-0.093*** (0.019)	-0.113*** (0.032)
time(log(Capital_Goods))	0.032*** (0.007)							
time(log(Energy))		0.006** (0.003)						
time(log(Durable_Consumer_Goods))			0.051*** (0.011)					
time(log(Non_Durable_Consumer_Goods))				0.006*** (0.001)				
time(log(Intermediate_Goods))					0.017*** (0.005)			
time(log(High_Technology))						0.007*** (0.002)		
time(log(Low_Technology))							0.002 (0.003)	
time(log(Medium_Low_Technology))								0.011*** (0.004)

Note:

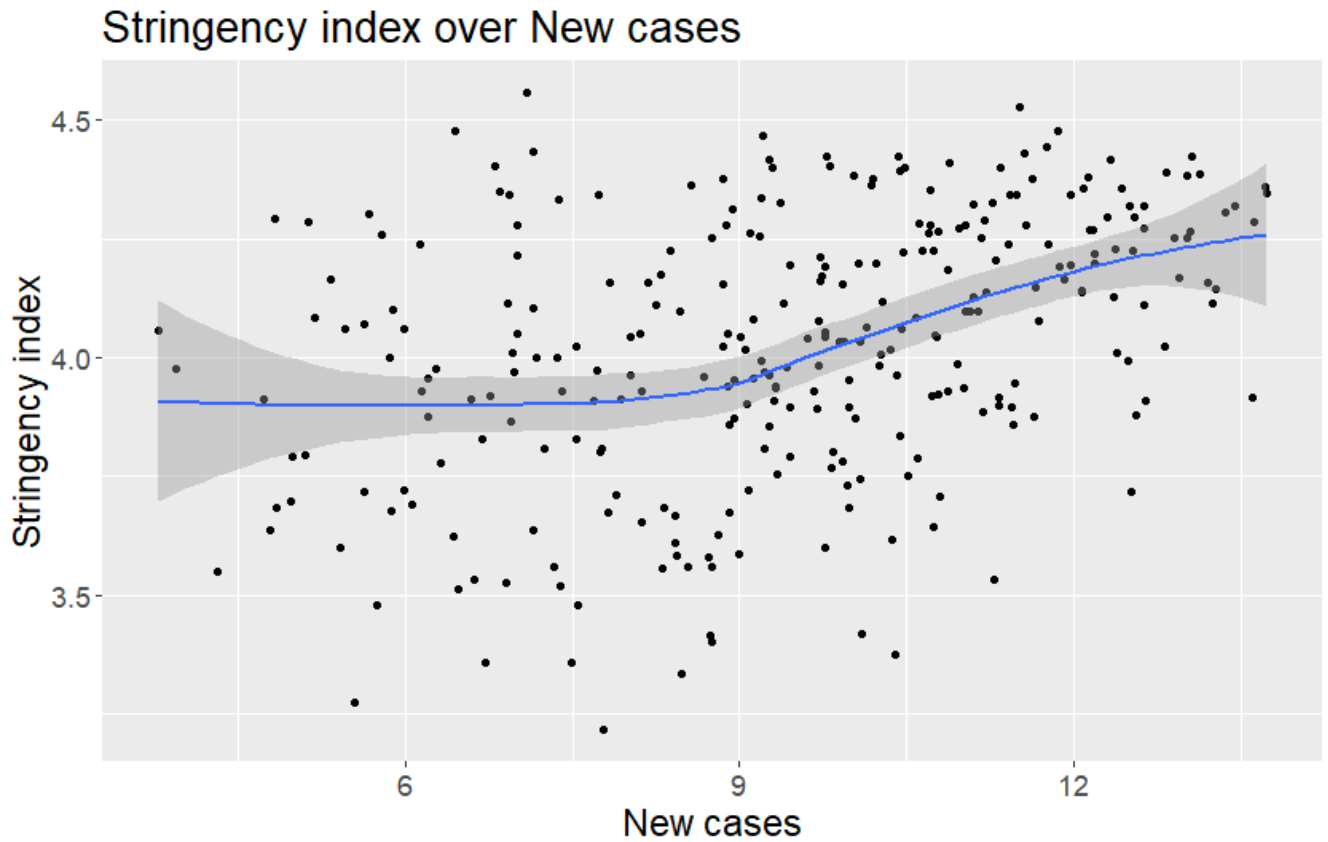
* p<0.1; ** p<0.05; *** p<0.01

Compiled by the author.

Figure 2 below represent the stringency index over the new cases registered in the 24 European Union countries in one graph. Both variables are under logarithm function, as stringency index takes values between 0 and 100, while number of new cases is varying and takes maximum value of 922124 cases per month. Also, logarithm function helps to see patterns of data easier than plotting raw data.

Figure 2

A figure showcasing stringency index over number of new cases



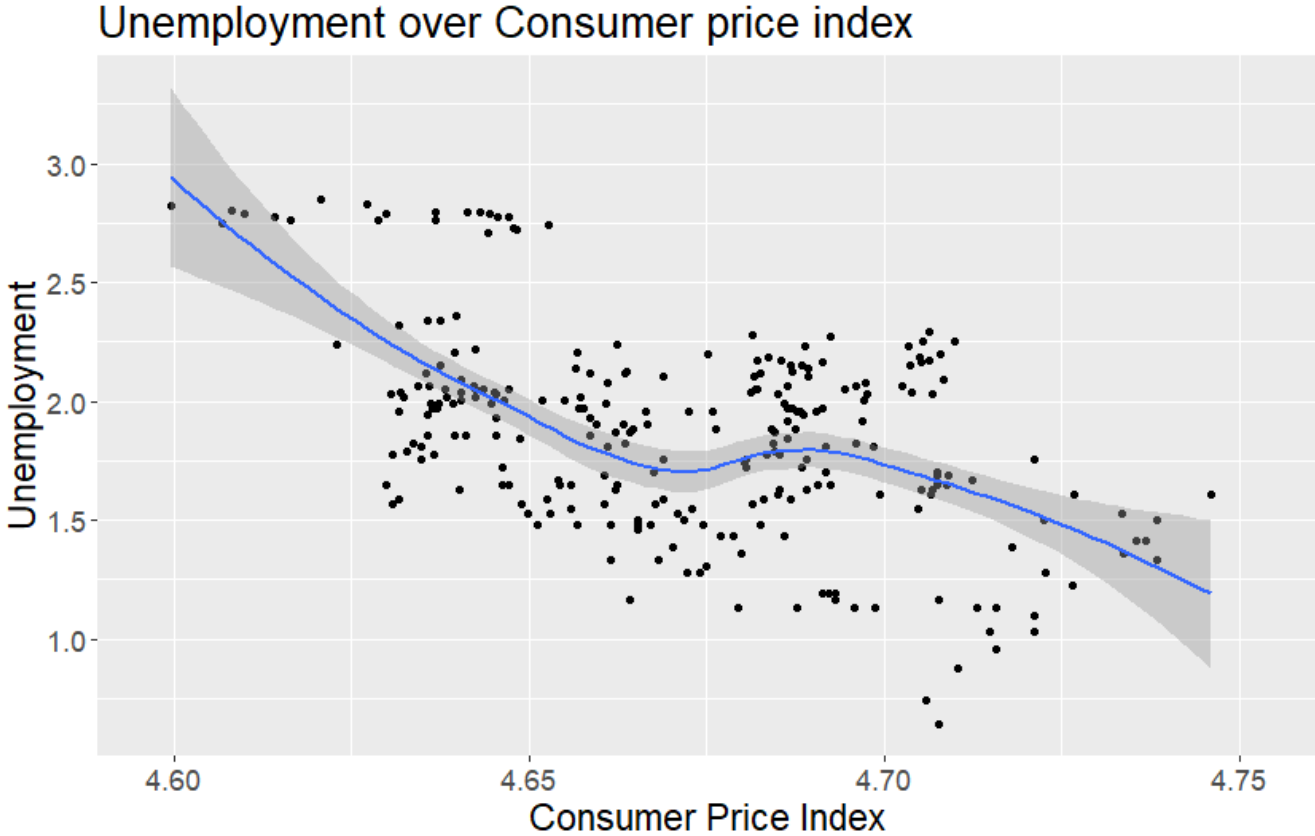
Source: compiled by the author using Eurostat data.

Figure 2 is useful to inspect if new cases and stringency case are endogenous and causing one another. It can be discussed, that with the increase in new cases in the country, government react to the situation by strightening policies in the next period, however the graph does not show strong correlation between variables.

Figure 3 shows consumer price index and unemployment over the analysed time period. It shows stronger relation than stringency index and new cases. It shows that majority of observations are near the middle and are clustering.

Figure 3

A figure showcasing unemployment over consumer price index

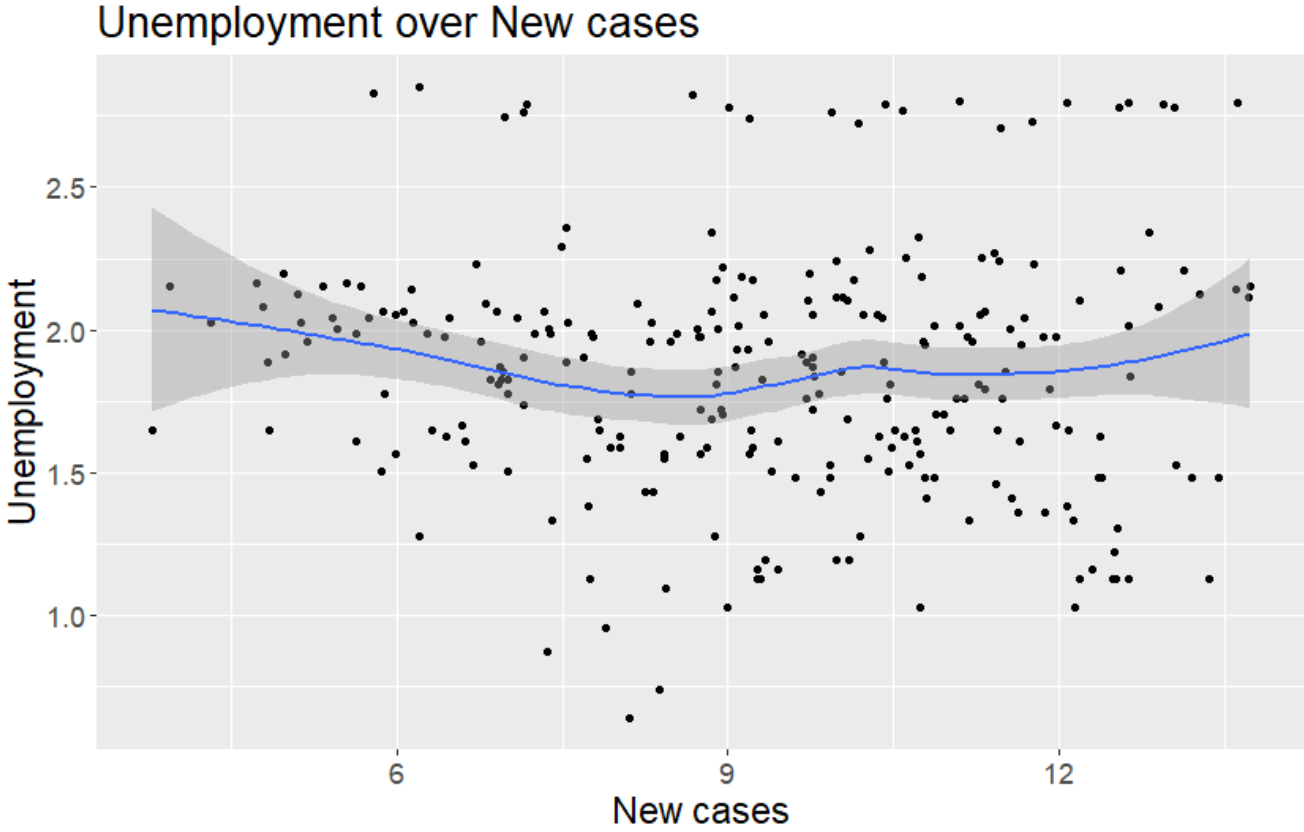


Source: compiled by the author using Eurostat data

Figure 4 shows unemployment over new cases indicated. Even though variables are under logarithm function, larger outliers are presents, while majority of data is clustered near the middle. It looks like variables could be causal and affect one another. With more available data the analysis could provide more insights and understanding.

Figure 4

A figure showcasing unemployment over number of new cases

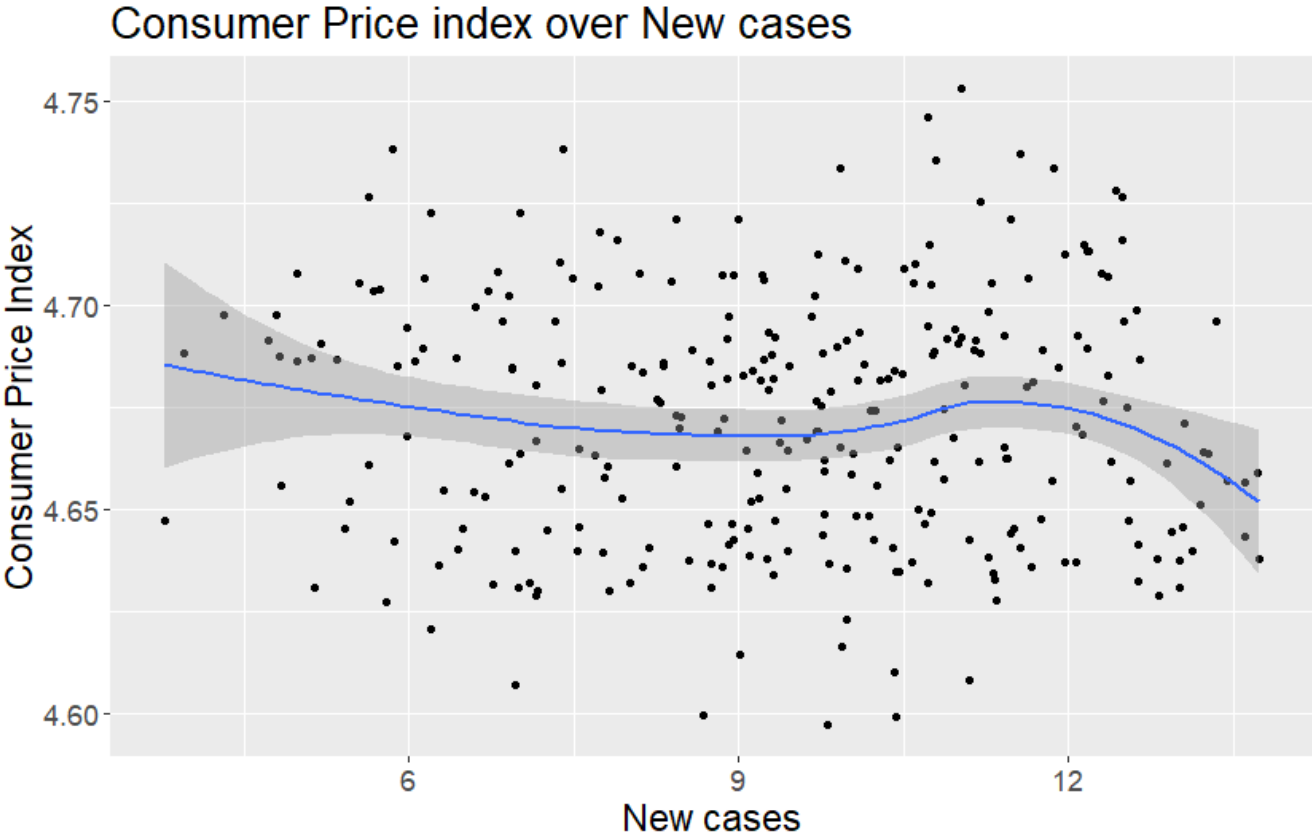


Source: compiled by the author using Eurostat data

Figure 5 shows consumer price index over new cases and it looks like data is not correlated and shows no pattern whatsoever. It is spread out mostly in the middle of graph randomly, without any clustering and only few observations fall under the grey area in the graph, that shows regression of the two variables.

Figure 5

A figure showcasing consumer price index over number of new cases

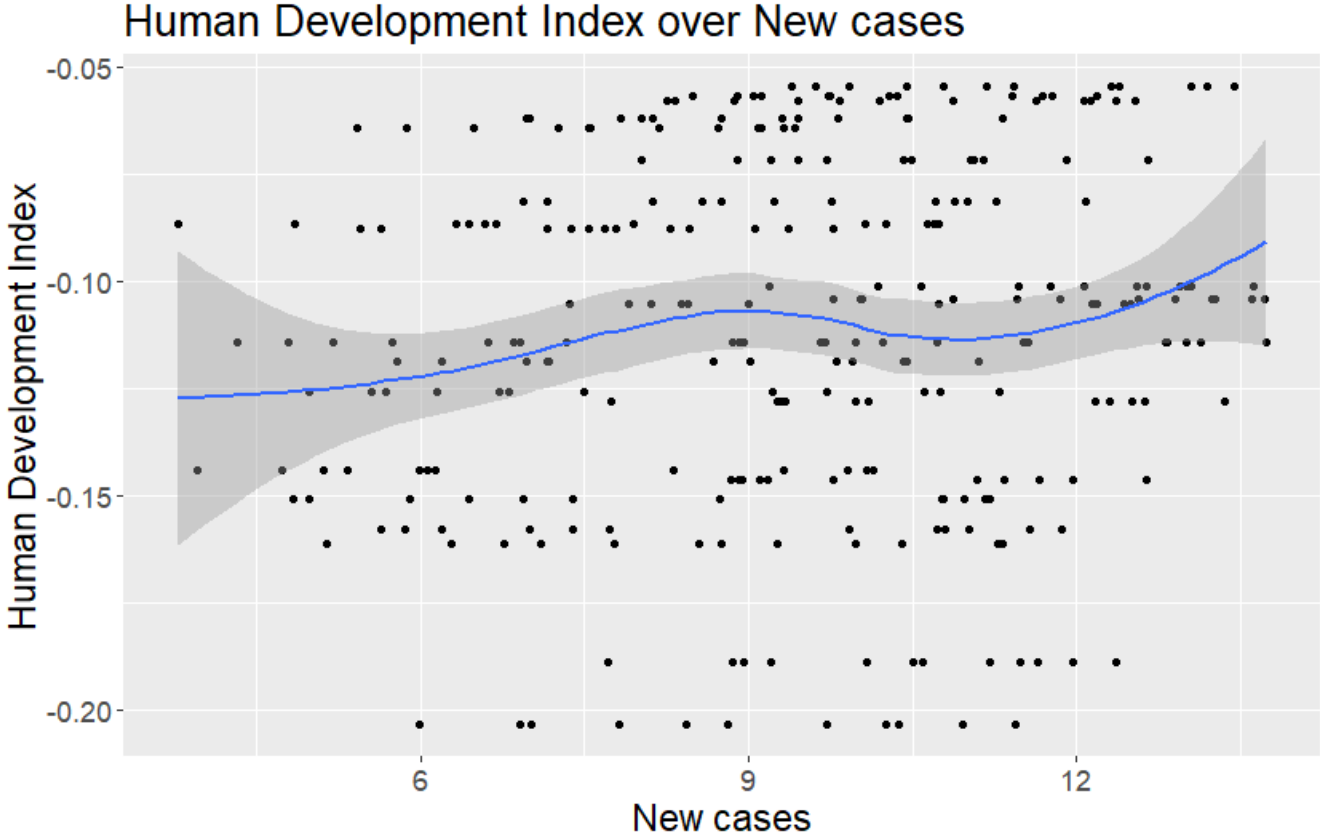


Source: compiled by the author using Eurostat data

Figure 6 shows how human development index look plotted against new cases. It is clear, that variables are not correlated and are set out in multilayers with large outliers even though both variables are under logarithmic functions. Human development was not present in the panel data regression as R omitted variable due to multicollinearity in panel regression. Looking at graph multicollinearity is not visible, however it was calculated in regression. After this graphical analysis it can be concluded that independent variables are not correlated with new cases, however unemployment and consumer price index show possible correlation.

Figure 6

A figure showcasing human development index over number of new cases



Source: compiled by the author using Eurostat data

Spatial analysis was conducted for 3 industries – intermediate goods, capital goods and non – durable consumer goods using cross – sectional data for monthly effects from 2020 – 03 to 2020 – 11. Tables below show the results obtained for each industry using monthly regressions. Regressions were conducted for spatial autoregressive lag and spatial Durbin model with Maximum likelihood estimation. Regression provides logarithmic variables and lags of those variables. For intermediate goods industry, no variable shows significant values for all months, however consumer price index and new cases show four significant values. Significant values from consumer price index show positive increase in the industry and other values even though are not significant, provide positive sign. New cases, like in simple regression, provide low values, however now negative sign is presented. Stringency index negatively

affects industry only at two time periods. Human development index provides negative, lowly significant impact at two times. Positive Log Likelihood proves that inclusion of lagged variables improved the model. As Lagrange Multiplier tests for absence of spatial autocorrelation in the lag model, spatial autocorrelation is found for time periods 2 – 9.

Table 7

Results of spatial analysis on industrial production index in intermediate goods industry

	<i>Dependent variable:</i>								
	log(Intermediate_Goods)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log(Consumer_price_index)	0.266 (1.718)	2.220 (3.185)	3.179* (1.860)	2.551 (1.577)	2.610** (1.029)	3.014*** (0.972)	2.256** (1.038)	2.545** (1.086)	1.570 (1.145)
log(Unemployment)	-0.035 (0.081)	0.047 (0.144)	0.131 (0.106)	0.071 (0.093)	0.118 (0.075)	0.159** (0.068)	0.081 (0.078)	0.086 (0.081)	0.010 (0.078)
log(New_Cases)	-0.040** (0.018)	-0.049** (0.024)	-0.022 (0.015)	-0.031* (0.018)	-0.035*** (0.010)	-0.035*** (0.011)	-0.017 (0.012)	-0.004 (0.013)	-0.012 (0.019)
log(Stringency_Index)	-0.290** (0.131)	-0.429 (0.493)	-0.019 (0.259)	-0.011 (0.189)	0.024 (0.063)	0.012 (0.069)	-0.098 (0.085)	-0.195** (0.090)	-0.015 (0.101)
log(Human_Development_Index)	-0.642 (0.916)	0.248 (1.282)	0.215 (0.775)	-0.470 (0.686)	-0.875* (0.454)	-0.327 (0.449)	-0.530 (0.509)	-0.749* (0.445)	-0.730 (0.513)
lag.log(Consumer_price_index)	-0.864 (1.912)	0.745 (3.152)	2.429 (2.402)	2.235 (2.175)	2.633* (1.506)	4.897*** (1.683)	2.165 (1.563)	1.528 (1.163)	0.947 (1.233)
lag.log(Unemployment)	-0.045 (0.090)	-0.061 (0.151)	0.084 (0.112)	0.121 (0.112)	0.096 (0.082)	0.196** (0.087)	0.061 (0.073)	-0.041 (0.069)	-0.002 (0.081)
lag.log(New_Cases)	0.012 (0.031)	-0.001 (0.037)	0.015 (0.023)	-0.005 (0.035)	-0.027 (0.019)	-0.034* (0.019)	-0.014 (0.023)	-0.026 (0.021)	0.020 (0.033)
lag.log(Stringency_Index)	-0.461** (0.226)	-0.560 (0.702)	-0.238 (0.423)	0.108 (0.407)	0.059 (0.158)	0.262 (0.206)	0.049 (0.199)	0.083 (0.197)	-0.186 (0.184)
lag.log(Human_Development_Index)	-1.182 (1.567)	-0.021 (2.755)	0.949 (1.635)	1.561 (1.479)	0.904 (0.861)	0.387 (0.725)	0.483 (0.922)	0.128 (0.878)	-0.099 (0.979)
Constant	12.126 (15.267)	-5.062 (24.575)	-22.567 (18.154)	-19.091 (16.831)	-19.248* (10.473)	-32.369*** (11.864)	-14.389 (10.908)	-11.939 (9.126)	-6.122 (8.870)
Observations	24	24	24	24	24	24	24	24	24
Log Likelihood	22.333	10.900	20.007	23.734	31.844	33.719	30.038	32.540	27.635
sigma ²	0.009	0.023	0.010	0.008	0.004	0.003	0.005	0.004	0.006
Akaike Inf. Crit.	-18.667	4.200	-14.013	-21.469	-37.688	-41.439	-34.076	-39.081	-29.271
Wald Test (df = 1)	3.072*	0.317	5.155**	1.175	0.741	1.166	2.055	3.764*	0.070
LR Test (df = 1)	1.659	0.214	3.297*	0.854	0.581	0.891	1.523	2.674	0.063

Note:

* p<0.1; ** p<0.05; *** p<0.01

Compiled by the author.

Spatial analysis for capital goods industry provided more significant values. Some are similar like for intermediate goods. Consumer price index positively and significantly increases capital goods for 6 periods of time. Unemployment also increases industry positively, however values are less significant. New cases provide 4 negative significant and relatively low values. Stringency index surprisingly have significant positive impact at the last time. More significant values of human development index have negative effect and one less significant positively affect capital goods industry. Lagged values provide more significant impact for human development index, stringency index and new cases, while consumer price index and unemployment are more significant without lagged values. Spatial autocorrelation is not found at the first time; however all other times provide spatial autocorrelation.

Spatial analysis of non – durable consumer goods provide overall significant positive influence on consumer price index for the industry. Unemployment has slight positive significant influence and new cases have a few significant, however not high values. Stringency index very similarly provide a few significant negative values that impact industry. Human development index showed positive and significant effect to non – durable consumer goods industry. Lagged variables do not seem to provide more insightful effects. Non – durable consumer goods provide spatial autocorrelation at all analysed times.

Overall, spatial autocorrelation was found in analysing three industries. Differently than what simple panel data analysis provided, new cases showed negative impact on industries in spatial analysis even though the impact of the variable is relatively small. Human development index, that was excluded from linear analysis, appeared in spatial analysis and it two industries showed negative impact and in one positive. For countries with lower human development index might be harder to compete in certain industries. Also, this index can be related with number of new cases confirmed, as in analysed literature it was identified, that countries with higher development indexes have better health system. Stringency index in spatial analysis is not as significant as it was in previous analysis, however it showed both positive and negative impact on industries. Unemployment and consumer price index both impact industries positively and more significantly, than in panel regression. It is mostly caused by the inclusion of spatial lag variables.

Table 8*Results of spatial analysis on industrial production capital goods industry*

	<i>Dependent variable:</i>								
	log(Capital_Goods)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log(Consumer_price_index)	5.435** (2.222)	6.779 (4.255)	2.096 (3.621)	5.140** (2.037)	2.652 (1.935)	4.280* (2.499)	4.541*** (1.608)	5.203*** (1.992)	3.198** (1.590)
log(Unemployment)	0.276*** (0.104)	0.443** (0.192)	0.146 (0.208)	0.174 (0.120)	0.196 (0.142)	0.309* (0.174)	0.296** (0.121)	0.275* (0.149)	0.203* (0.109)
log(New_Cases)	-0.045* (0.023)	-0.113*** (0.033)	-0.047 (0.029)	-0.074*** (0.023)	-0.038** (0.019)	-0.032 (0.029)	-0.016 (0.020)	-0.013 (0.024)	-0.010 (0.026)
log(Stringency_Index)	-0.194 (0.171)	0.831 (0.674)	0.325 (0.506)	0.242 (0.243)	-0.046 (0.119)	0.017 (0.179)	-0.140 (0.132)	0.164 (0.164)	0.291** (0.145)
log(Human_Development_Index)	-0.041 (1.184)	2.255 (1.712)	1.378 (1.518)	1.495* (0.885)	-0.262 (0.867)	-0.627 (1.183)	-0.915 (0.807)	-2.463*** (0.828)	-2.105*** (0.717)
lag.log(Consumer_price_index)	-0.474 (2.498)	-0.515 (4.199)	-0.777 (4.646)	6.736** (2.802)	1.079 (2.823)	3.136 (4.417)	1.073 (2.430)	-0.898 (2.089)	-1.643 (1.661)
lag.log(Unemployment)	-0.063 (0.118)	-0.057 (0.206)	-0.113 (0.220)	0.248* (0.145)	-0.018 (0.157)	0.076 (0.230)	0.030 (0.117)	-0.212* (0.127)	-0.220* (0.113)
lag.log(New_Cases)	0.003 (0.040)	-0.059 (0.053)	-0.011 (0.046)	-0.117*** (0.045)	-0.067** (0.034)	-0.071 (0.049)	-0.067* (0.035)	-0.107*** (0.039)	0.048 (0.047)
lag.log(Stringency_Index)	-0.747** (0.293)	-2.250** (0.920)	0.398 (0.831)	1.883*** (0.528)	0.158 (0.301)	0.310 (0.537)	-0.007 (0.310)	0.157 (0.360)	-0.932*** (0.262)
lag.log(Human_Development_Index)	3.741* (2.115)	4.114 (3.725)	2.776 (3.247)	4.250** (1.895)	2.126 (1.607)	2.264 (1.877)	3.825*** (1.430)	3.672** (1.607)	3.151** (1.364)
Constant	-14.353 (19.724)	-17.324 (32.843)	-3.944 (35.310)	-59.749*** (21.838)	-10.448 (19.797)	-29.736 (31.059)	-18.317 (16.941)	-13.285 (16.588)	-0.614 (12.347)
Observations	24	24	24	24	24	24	24	24	24
Log Likelihood	16.734	4.020	4.766	17.070	15.582	10.579	18.763	17.889	19.768
sigma ²	0.015	0.042	0.039	0.013	0.015	0.024	0.011	0.012	0.011
Akaike Inf. Crit.	-7.467	17.960	16.469	-8.140	-5.165	4.841	-11.526	-9.779	-13.535
Wald Test (df = 1)	0.021	0.024	0.001	4.846**	5.553**	1.274	6.221**	5.155**	0.239
LR Test (df = 1)	0.013	0.014	0.001	2.455	3.142*	0.864	3.774*	3.177*	0.174

Note:

* p<0.1; ** p<0.05; *** p<0.01

Compiled by the author.

Table 9*Results of spatial analysis on industrial production non – durable goods industry*

	<i>Dependent variable:</i>								
	log(Non_Durable_Consumer_Goods)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log(Consumer_price_index)	2.084*	1.716*	2.207	1.492	1.716*	2.204**	2.957***	3.814**	2.499**
	(1.187)	(0.886)	(1.819)	(1.400)	(0.886)	(1.089)	(0.814)	(1.494)	(1.190)
log(Unemployment)	0.076	0.071	0.003	0.068	0.071	0.101	0.164***	0.237**	0.114
	(0.056)	(0.065)	(0.105)	(0.084)	(0.065)	(0.077)	(0.062)	(0.111)	(0.081)
log(New_Cases)	-0.030**	-0.010	-0.028*	-0.005	-0.010	-0.026**	-0.020**	0.018	-0.012
	(0.012)	(0.009)	(0.015)	(0.016)	(0.009)	(0.012)	(0.010)	(0.017)	(0.020)
log(Stringency_Index)	-0.163*	0.010	0.246	-0.118	0.010	0.143*	-0.011	-0.255**	-0.089
	(0.088)	(0.057)	(0.255)	(0.169)	(0.057)	(0.079)	(0.066)	(0.122)	(0.104)
log(Human_Development_Index)	2.010***	0.574	1.875**	0.943	0.574	1.050**	1.333***	1.103*	1.196**
	(0.618)	(0.397)	(0.758)	(0.610)	(0.397)	(0.512)	(0.395)	(0.609)	(0.530)
lag.log(Consumer_price_index)	3.060**	-0.046	2.239	1.306	-0.046	1.437	3.633***	2.965*	2.331*
	(1.291)	(1.296)	(2.325)	(1.923)	(1.296)	(1.915)	(1.188)	(1.550)	(1.258)
lag.log(Unemployment)	0.164***	0.013	0.138	0.153	0.013	0.113	0.167***	0.026	0.109
	(0.061)	(0.071)	(0.110)	(0.100)	(0.071)	(0.098)	(0.056)	(0.094)	(0.084)
lag.log(New_Cases)	-0.004	0.003	0.019	0.033	0.003	-0.022	-0.039**	-0.043	-0.031
	(0.020)	(0.015)	(0.023)	(0.031)	(0.015)	(0.021)	(0.017)	(0.029)	(0.034)
lag.log(Stringency_Index)	-0.136	-0.333**	-0.371	-0.496	-0.333**	-0.110	0.160	0.302	-0.053
	(0.154)	(0.138)	(0.420)	(0.359)	(0.138)	(0.233)	(0.153)	(0.268)	(0.189)
lag.log(Human_Development_Index)	2.267**	1.734**	0.860	1.520	1.734**	1.927**	2.453***	2.545**	1.918*
	(1.143)	(0.753)	(1.645)	(1.312)	(0.753)	(0.854)	(0.763)	(1.251)	(1.017)
Constant	-15.805	0.243	-15.366	-4.772	0.243	-10.528	-23.972***	-25.537**	-14.880
	(10.296)	(9.069)	(17.714)	(14.945)	(9.069)	(13.444)	(8.391)	(12.504)	(9.160)
Observations	24	24	24	24	24	24	24	24	24
Log Likelihood	31.355	34.352	21.301	26.257	34.352	30.415	35.447	25.330	26.093
sigma ²	0.004	0.003	0.010	0.006	0.003	0.004	0.003	0.007	0.006
Akaike Inf. Crit.	-36.710	-42.704	-16.603	-26.513	-42.704	-34.831	-44.893	-24.660	-26.187
Wald Test (df = 1)	6.256**	5.934**	0.029	3.178*	5.934**	3.096*	9.134***	2.483	5.520**
LR Test (df = 1)	4.915**	5.281**	0.023	2.104	5.281**	2.782*	7.076***	2.742*	3.854**

Note:

* p<0.1; ** p<0.05; *** p<0.01

Compiled by the author.

CONCLUSIONS AND RECOMENDATIONS

After analysing panel data for 24 European Union countries (Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden) and the effect that was evidential in the industries analysed (capital goods, durable consumer goods, non - durable consumer goods, energy, high technology, low technology, medium - low technology, intermediate goods) .

As two different analysis were performed in the paper, surprisingly both showed rather different results. Simple panel regression showed that stringency index has the highest negative influence for all the industries. Consumer price index showed different results, positive and negative depending on the industry analysed. Unemployment showed positive impact on industries. New cases registered provided positive impact and low values and proved a limitation of the analysis in the paper. Possible explanation can be endogeneity with stringency index for new cases, results are not intuitive and defensible. Another explanation for positive impact can be the missing spatial lag, as simple analyses usually is not able to find spatial autocorrelations.

When time trend was used, in simple panel regression with fixed effects capital goods and low technology industries were affected positively and significantly by consumer price index and other industries showed negative impact. Unemployment showed mostly positive impact for some industries and significant only for durable consumer goods. With clustered error term, consumer price index and unemployment lost all significance and only stringency index remained fully significant, as new cases showed few significant values, however still with positive impact on analysed industries. Provided results does not seem to be intuitive and show limitations of the paper. Used time trend showed mainly positive, even though small unemployment impact on industries, which can be caused by causality that because of COVID-19 firms that did not laid employees received benefits, while those who fired their employees did not, while employees that lost their workplace also received additional benefits. With overall increase of unemployment firms and those who lost work received additional benefits.

Different situation appeared when spatial analysis was conducted. Even though analysis was conducted for cross – sectional data, it showed more intuitive results than panel data analysis. Spatial autocorrelation was found only on three industries analysed. Results showed that stringency index is not as significant as it was anymore. Stringency index showed significant and negative impact for most of the time observed in the regressions conducted, however some results showed positive impact. It could

be the case, that spatial panel data would show strictly negative impact, as intuitively increase in stringency should not increase industrial production index. Unemployment and consumer price index appeared to be the most significant and positively impacting analysed industries - intermediate goods, capital goods and non – durable consumer goods. Unemployment showed mostly positive impact and it lets to conclude that due to endogeneity it shows positive impact. Consumer price index showed mostly positive impact on analysed industries. It could either show causality or strengthen the idea of lack in household financial responsibility and rationality during crisis. Human development index, that was excluded from panel data analysis, was significant and positively affecting industries. It supports the idea that was discussed in literature review, that countries with higher human development index have access to better health care system and therefore have a better control of COVID-19 outbreak. Most important, new cases variable in spatial analysis showed low negative impact on industries.

Limitations in this thesis are the endogeneity of unemployment with the analysed industries, as it is possible that unemployment is influenced by the decreases or increases in any of the industries. To control it, instrumental variables should be used. Another limitation is limited time sample, therefore this model could be analysed again in future when more data is available.

As recommendations I would suggest that countries should take a strong consideration and elevate the release of policies carefully, taking into account constant change of COVID-19 cases in countries. If industries prove to be keeping stable growth and performance and stringency index have a low impact like in energy, low technology and high technology industries, government could act in the long run and keep stricter policies to decrease the spread of COVID-19 as much as possible. However, if main industry in country is capital goods or durable consumer goods, keeping strict policies can cause high disruptions in economic variables and low performance of the firms. Overall, the main goal of the government should be long – term stability, which can be achieved by omitting the threat of COVID-19. It should be achieved by focusing on vaccinating the majority of people in country which would lead to coming back to the lifestyle before the lockdowns. Even though recession threat is possible, economy should recover once all industries will be able to fully work and people will be able to travel without restrictions.

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SPATIAL ANALYSIS OF COVID-19 IMPACT ON INDUSTRIES

KOTRYNA STANKAITYTĖ

Bachelor Thesis

Quantitative economic programme

Faculty of Economics and Business Administration of Vilnius University

Supervisor – PhD. Povilas Lastauskas

Vilnius, 2021

SUMMARY

40 pages, 6 figures, 9 tables, 27 references.

The main objective of the academic paper was to analyse the existence of spatial autocorrelation in 24 European Union countries during COVID-19 outbreak and to determine its impact on industries. This paper consists of three main parts – literature and theory analysis, empirical analysis, recommendations, and conclusions.

The main goal of literature and theory analysis was to determine main concepts of spatial analysis during COVID-19 outbreak and determine specialties of industrial analysis during crisis to find already existing models and approaches. This section provides deeper theoretical understanding and different approaches and results to similar topics.

Empirical analysis is divided into three models. First two model presented are panel regression with fixed effect and similar models. Simple analysis showed that stringency index is the main determinant and affects industries negatively, while other variables provided less significant values. Augmented time trend model concluded that only stringency index had all negative and significant values and few values of new cases had significant small positive impact. Spatial analysis, that was conducted for three industries with cross – sectional data, that showed spatial patterns, revealed that mostly influencing variables are consumer price index human development index and unemployment. New cases showed small negative impact and stringency index showed both positive and negative impacts.

The conclusions and recommendations section provides insights on difference in analysis and emphasizes on importance of consistency in policy application at country level.

ERDVINĖ COVID-19 POVEIKO ANALIZĖ PRAMONEI

KOTRYNA STANKAITYTĖ

Baigiamasis bakalauro darbas

Kiekybinės ekonomikos programa

Vilniaus Universiteto Ekonomikos ir verslo administravimo fakultetas

Vadovas – PhD. Povilas Lastauskas

Vilnius, 2021

SANTRAUKA

40 puslapių, 6 grafikai, 9 lentelės, 27 literatūros šaltiniai.

Pagrindinis šio darbo tikslas buvo nustatyti erdvinio ryšio egzistavimą 24 Europos Sąjungos šalyse COVID-19 protrūkio metu ir nustatyti įtaką pramonės industrijoms. Šį darbą sudaro pagrindinės 3 dalys – literatūros ir teorijos aprašymas, analizė ir jos rezultatai, išvados ir rekomendacijos.

Literatūros ir teorijos analizė buvo skirta nustatyti pagrindinius erdvinės analizės konceptus COVID-19 protrūkio metu ir nustatyti pramonės industrijų analizės ypatumus krizės metu ir rasti jau sukurtus sėkmingus modelius ir metodus.

Analizės dalis padalinta į tris pagrindines dalis. Pirmieji 2 modeliai analizuoja laiko eilučių regresijas su fiksuotais efektais. Paprastoji regresija nustatė, kad griežtumo indeksas yra svarbiausias kintamasis, kuris veikia pramonės industrijas neigiamai. Kiti kintamieji pateikė mažiau reikšmingas vertes. Papildytas laiko tendencijos modelis nustatė, kad griežtumo indeksas yra svarbiausias ir reikšmingiausias kintamasis, neigiamai veikiantis industrijas, o nauji nustatyti atvejai yra nežymiai reikšmingi, tačiau teigiamai veikia industrijas. Erdvinė analizė buvo vykdomas trims industrijoms, kurios parodė egzistuojantį erdvinį efektą. Ši analizė nustatė, kad svarbiausi kintamieji, kurie veikė industrijas teigiamai yra vartotojų kainų indeksas, nedarbas ir žmonių raidos indeksas. Nauji nustatyti COVID-19 atvejai parodė nedidelį neigiamą reikšmingą poveikį analizuotoms industrijoms, o griežtumo indeksas parodė tiek teigiamą, tiek neigiamą poveikį industrijoms.

Išvadų ir rekomendacijų dalis apibendrina skirtumus tarp analizuotų regresijų ir modelių ir pabrėžia taikomų strategijų tęstinumo svarbą šalies lygyje.