

ESSPIN

Economic, **S**ocial and **SP**atial **IN**equalities in Europe in the Era of Global Mega-trends

D4.x Differences in local resilience to COVID-19 in Poland.

Endogenous determinants versus the aftermath of public policies.

June 2024

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Executive Summary

Issue

- From the perspective of developmental cohesion, an important issue is how COVID-19 affected the pre-existing inequalities between different areas of the country.
- This study aims to better understand these issues through an analysis conducted at the level of Polish municipalities.

Research questions

- Did the pandemic reduce these inequalities, or did they intensify?
- What was the role of local endogenous characteristics in mitigating the impact of COVID-19?
- What was the role of public policies – both long term ones and ad-hoc reactions to the pandemic?

Main findings

- We observe a conditional convergence of both excess mortality and revenues during covid: Excess mortality was higher in places with relatively low mortality before the pandemic. Similarly, higher average revenues before the pandemic are associated with lower growth of revenues during COVID-19.
- Excess mortality is higher in municipalities with older, less educated population, and these located further from the main regional cities. Regional policies targeting innovation spending have not sustained the recovery of regions and have amplified interregional inequalities, confirming the existence of a tension between directing resources towards less developed regions and nurturing innovation.
- When it comes to the revenues, communities with higher proportion of educated and politically active population and higher share of agricultural land in the total area were better off during the pandemic

Policy implications

- Local resilience against the pandemic clearly depends on the quality of public policies, but this refers mostly to the long-term policies, a to much less extent – to the activities took in reaction to the outbreak of COVID-19.
- Local policy efforts might have been helpful in mitigating the pandemic impact. In contrast, there is no effect of government grants on mortality. Public spending had no effect at all on the change in personal revenues during the pandemic.

1. Introduction

The COVID-19 epidemic, which peaked in 2020-2021, caused severe social and economic impacts in many countries around the world. Its most significant consequence is the death of many individuals infected with the virus. It is estimated that the number of victims who died directly due to the infection or due to complications amounted to approximately 7 million globally. In Poland, which is the subject of this study, the mortality during the pandemic amounted to about 120,000 people.

In addition to health impacts, the epidemic was also a source of economic crisis. Preventive measures taken by most countries, primarily "lockdowns," which involved drastic restrictions on the mobility and activities of residents and businesses, caused a global recession that, however, varied in duration and intensity. In Poland, a short-term decline in GDP occurred in the first half of 2020.

From the perspective of developmental cohesion, an important issue is how COVID-19 affected the pre-existing inequalities between different areas of the country. Did the pandemic reduce these inequalities, or did they intensify? This question is relevant and significant in both health (mortality rates) and economic (income levels) contexts. It should be assumed that the impact of the pandemic on territorial cohesion may result from both the endogenous characteristics of individual territories and the shape and quality of policies implemented both during and before the pandemic.

This study aims to better understand these issues through an analysis conducted at the level of Polish municipalities.

2. Outline of literature background

2.1. Could pandemic petrify / reduce territorial inequalities? Possible channels

There are several reasons why the impact of the pandemic may be uneven in different locations within a given country. First, the virus spreads according to specific spatial patterns. In the first phase of the pandemic, for example, infections appeared due to the presence of a significant number of people in tourist locations. The pandemic could also have been facilitated by mass events or the presence of specific services, such as care for the elderly (Borsati et al., 2022). Since COVID-19 is particularly dangerous for older people, the demographic structure of local populations could also determine the varied intensity of infections and deaths in different locations (Biggeri et al., 2020).

Although theoretically, the virus can attack people from different social classes equally easily, there is no doubt that wealth and living conditions influenced the chances of infection and the possibility of death, due to differences in access to information, the quality of healthcare, the

ability to take precautions without losing livelihoods, etc. (Brandily et al., 2020). This means that areas of the country inhabited by people with higher socio-economic status might have been less exposed to the effects of the pandemic.

An important element of status is also the level of education. In the context of exposure to the effects of COVID-19, education can play a significant role, as it is correlated with awareness of the threat, the level of trust in the vaccination program, and the degree of resistance to misinformation and conspiracy theories (Bello & Rocco, 2022).

The effects of the pandemic may also depend on how the local community responds to the threat and the associated restrictions and regulations. Discipline in the face of danger, the presence of strong leadership, and the degree of self-organization are elements of culture that certainly differ significantly on an international scale, but also within a country, between smaller territorial units (Imai & Ji, 2021). Additionally, because countries are territorially diverse in terms of citizens' political views, the level of trust in the currently ruling party or coalition, which was responsible for implementing anti-pandemic regulations that strongly limited civil liberties and often hit the economic interests of voters, may play an important role (Farzanegan & Hoffman, 2022).

Many studies have proven the effectiveness of COVID-19 vaccinations as a method of preventing illness and serious consequences of potential infection (Rahmani et al., 2022). Therefore, a factor differentiating territorial risk related to the pandemic should be the availability of the vaccines themselves. While this factor played a smaller role in developed countries, where there were no significant differences in vaccine availability within the country, it is crucial in international comparisons.

The varied access to healthcare infrastructure could also translate into spatial inequalities regarding the negative effects of the pandemic (Juárez-Ramírez et al., 2022). This pertains to both the availability of basic outpatient care and the ability to find care in specialized hospitals. In the latter case, the distance between the patient's residence and the hospital facility, as well as the quality of road infrastructure, can play a key role.

As for the economic effects of the COVID-19 epidemic, they can be territorially diverse due to the different sectoral structure of local economies (Desdiani et al., 2022). Due to the nature of pandemic restrictions, certain industries proved particularly vulnerable to the crisis – for example, tourism and gastronomy. On the other hand, economies with a significant share of the public sector should be more resilient to the crisis.

2.2. Role of public policies in preventing negative outcomes of COVID-19 in Poland

One natural example of a key policy in the presence of the COVID-19 pandemic refers to the supply and distribution of vaccines. In Poland provision of vaccines was a mixed responsibility of central government and local authorities. General regulations were uniform for the whole territory of Poland, so in theory their implementation should have no effect on territorial inequalities (Law on COVID-19, 2020). On the other hand though, government's general performance in supplying vaccines along with local performance in preparing the infrastructure might have had differential effect on municipalities due to existing local preconditions.

In the context of the pandemic, easy access to health care facilities including hospitals and local clinics were crucial to mitigate the adverse outcomes. Provision of basic health services in Poland is a local responsibility. Most public clinics are run by county (powiat) administration. However for citizens residing in rural areas and small towns, quality of road infrastructure is an important factor conditioning fast access to the nearest big city (with specialized health services). Building and maintaining roads is a joint local/regional/central responsibility, depending on the classification of the road (Olejniczak-Szałowska, 2000).

To prevent the spread of the virus, and to mitigate its effects, Polish authorities at both central and local level launched several policy programmes. The largest programme (Fundusz Przeciwdziałania COVID-19, PLN 190 billion) was administered by the state owned BGK Bank. It was aimed to reduce the negative impact on COVID-19 both in public health, and other sectors of the economy (Law on Covid-19, 2020; <https://www.bgk.pl/programy-i-fundusze/fundusze/fundusz-przeciwdzialania-covid-19/>). There were also numerous smaller initiatives at the regional and local level.

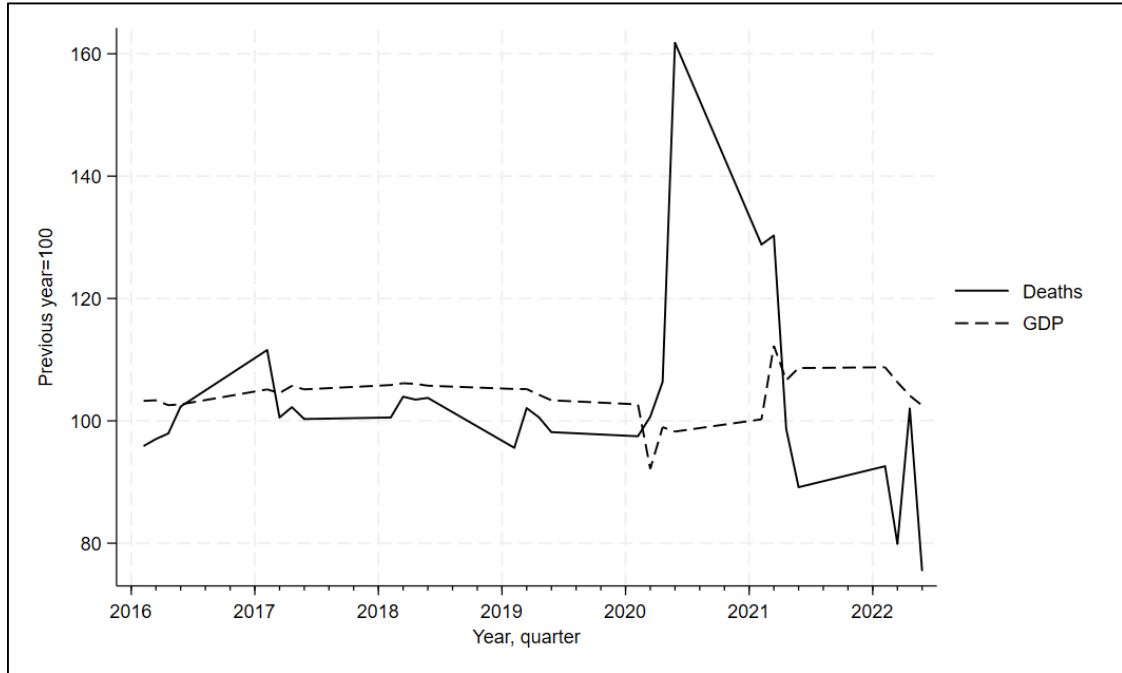
Central government was responsible for the country-wide information campaign, aimed at promotion of vaccination programme and persuading the citizens to comply with the restrictions. Unfortunately, the pandemic occurred in the period when the Polish government was led by the populist, right-wing party Law and Justice (PiS). In the early phase of the pandemic, the representatives of this party openly downplayed the pandemic threat, and questioned the necessity of lockdowns and other preventive measures. This could hamper the effectiveness of anti-covid measures, particularly in territories with large numbers of government's supporters. On the other hand, once the measures were finally administered, trust towards the government could cause more respectful attitude towards the new regulations (Farzanegan & Hoffman, 2022). Indeed, surveys taken in late 2020 show that at this point government supporters considered the pandemic more dangerous than did other voters (CBOS 2020).

3. Data

3.1 Dependent variables

Our two dependent variables refer to the impact on the pandemic on mortality and economic development. In both cases, the adverse effects of COVID-19 were clearly visible the scale of the whole country (see figure 1)

Figure 1: Mortality and GDP levels in Poland in 2016-2022. Same quarter in previous year=100



We conduct our research at the level of municipality. There are 2477 municipalities in Poland. In terms of effect on health, we rely on the measure of “excess mortality” defined as:

$$xm_i = \left(\frac{m_{i_pand}}{p_{i_pand}} - \frac{m_{i_pre}}{p_{i_pre}} * [\sigma_i] \right) * 1000, \text{ where:}$$

$\frac{m_{i_pand}}{p_{i_pand}}$ denotes mortality per capita during the pandemic years in municipality i (average value for 2020-2022)

$\frac{m_{i_pre}}{p_{i_pre}}$ denotes mortality per capita in the period preceding the pandemic in municipality i (average value for 2016-2019)

σ_i denotes a forecasted counterfactual trend in mortality for each municipality, simulating the scenario without the occurrence of COVID-19. To obtain this parameter we estimated fixed ARIMA AR(3) models based on the sample of 2003-2019 for each municipality. Forecasts from the models gave us the “expected” number of deaths that would occur if the previous trends

specific for a particular municipality would continue in 2020-2022. Comparing these forecasts with the actual number of deaths during the pandemic period enabled us to assess the excess mortality due to Covid-19.

As for the effect on economic development, we cannot use GDP, as it is not available at the local (municipal) level. Instead, we measure the difference between the average personal revenues as reported by individual taxpayers from each municipality in the pandemic year of 2021 and the expected revenues based on 2019 value and the average trend observed in the pre-pandemic period 2014-2019) :

$$\Delta rtp_i = \left(\frac{r_{i_pand}}{tp_{i_pand}} - \frac{r_{i_pre}}{tp_{i_pre}} * [\gamma_i] \right) / \frac{r_{i_pre}}{tp_{i_pre}}, \text{ where:}$$

$\frac{r_{i_pand}}{tp_{i_pand}}$ denotes revenues per taxpayer in 2021 in municipality i

$\frac{r_{i_pre}}{tp_{i_pre}}$ denotes revenues per taxpayer in 2019 in municipality i

$[\gamma_i]$ denotes a forecasted counterfactual trend in revenues for each municipality, simulating the scenario without the occurrence of COVID-19. The parameter γ_i is calculated as an average two-year change in personal revenues observed in municipality i within the period 2014-2019.

3.2. Independent variables

Table 1 lists all dependent and independent variables used in the analysis. Within the latter category we distinguish the variables which are directly related to some policy area at either central or local level. Their inclusion in the model specifications allows us to assess whether these particular policies had impact on either mortality or personal revenues during the pandemic outbreak. More specifically, we investigate on whether the adverse effects of COVID-19 were correlated with:

- Accessibility of local health infrastructure (health care policy, local level)
- Availability of vaccines (health care policy, central level)
- Time of access to large cities (transport policy, mixed levels)
- Information campaign and political message from the government (information policy, central level)
- Publicly funded programs and projects implemented during the pandemic (mixed levels)

Each specification will also include the base (pre-pandemic) levels of respective dependent variables, that is mortality or revenues. This mimics the approach used in the classical investigation on beta convergence. Hence we will be able to assess whether we observed a territorial convergence or a territorial divergence in terms of each of dependent variables during the pandemic period.

Table 1: Dependent and independent variables

Variable	Description	Source
Dependent		
excess_mortality	Mortality level as compared to the no-covid scenario	GUS
excess_revenue	Average personal revenues compared to the no-covid scenario	MF
Independent – policy related		
local_clinics_pre_covid	Health clinics per 10k of population, before COVID	GUS
perc_vaccinated	Percent of population fully vaccinated as for 08/21	MZD
car_access_woj	Access time to regional capitol, by car	IGiPZ
PiS_2019	Percent of supporting PiS (ruling, right-wing party) in parliamentary election 2019	PKW
Change_target_grants	Percent change in the amount of targeted grants received by the local authorities from the central government: 2020/2021 average compared to 2016/2019	GUS
Change_local_spending	Percent change in local government spending not funded by targeted grants:2020/2021 average compared to 2016/2019	GUS
Independent – other		
election_turnover	Turnover in parliamentary election in 2019	PKW
mortality_pre_covid	Yearly deaths per 1000 of population, before COVID	GUS
pop_density_pre_covid	Population density, before COVID	GUS
perc_retirement_pre_covid	Percent of population in retirement age, before COVID	GUS
tourist_beds_pre_covid	Beds in hotels and other tourist facilities, before COVID	GUS
perc_higher_edu	Percent of population with a higher education degree 2021	GUS
Dominicantes	Percent of population attending Sunday mass 2008	ISKK
log_revenues_pre_covid	Log of average personal revenues in 2019	MF
log_income_pre_covid	Log of average personal income in 2019 (log_doch_pit_2019)	MF
Income_revenue_ratio_pre_covid	Ratio of personal revenues to personal income in 2019. (High ratio means low cost of gaining the income, which is typical for permanent job contracts. High costs and thus low ratio are typical for entrepreneurial activity)	MF
share_agri_pre_covid	Share of agricultural farms in total area before COVID	GUS
municipality_type	Administrative status of municipality: urban; rural; mixed	GUS

4. Methodology

We start by visualizing the spatial pattern of dependent variables on maps (municipal level, 2477 observations). This let us observe the territorial differences in COVID-19 outcomes, but also gain intuition on possible channels explaining its uneven impact.

In the second step we run OLS regression for each dependent variable. We use the same set of explanatory variables, except for the base levels of dependent variables, which are specific to each take. We also ran spatial regressions (with spatially lagged dependent variables and selected independent variables) to test for potential diffusion effects and possibly inadequate aggregation level of our data, but it turned out that they do not provide any additional explanatory power, so we abandoned them.

In the final step we use machine learning algorithms (SVR and Random Forest) to assess the importance of particular variables while allowing non-linear relationships. Similarly to OLS, Support Vector Regression (Vapnik, 1995) fits a hyperplane that is positioned as close to all data points as possible. However, while OLS minimizes the sum of squared errors, SVR tries to fit the errors within a specified distance from the hyperplane (Smola and Schölkopf, 2004).

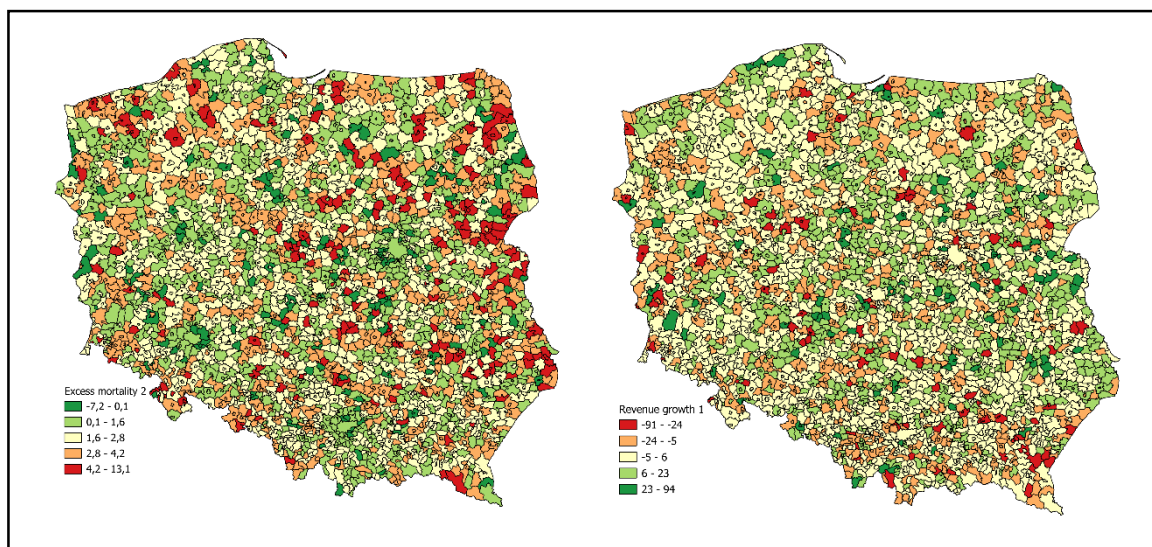
Moreover, the setup includes additional regularization hyperparameter C , which controls how much one wants to avoid misclassifying each observation. The most important advantage of SVR over OLS is the ability to model non-linear relationships between variables using selected kernel functions. SVR applies an implicit non-linear mapping into a higher dimensional feature space, where it is more probable to find an appropriate hyperplane (Vapnik, 1995). Thus, one can think of SVR as a process of performing a linear regression in a more dimensional space. Two widely used types of kernels are radial basis function and polynomial kernel. We applied the latter one in our empirical analysis.

Random forest (Breiman, 2001) is a combination of tree models. Each tree is trained on a different bootstrap subsample of the original dataset. In addition, at each split of each tree, only a random subset of all predictors is considered. Random forests are generally robust to the problem of multicollinearity and can be applied to a large number of potential predictors without initial selection. In addition, they are indifferent to non- linear interlinkages between the data.

5. Results

Excess mortality during the pandemic shows clear territorial pattern. Municipalities located along the eastern border of the country were hit most severely. Another cluster with high excess mortality is observed in the north-west (Zachodniopomorskie region). In contrast, in major metropolitan areas (Warsaw, Wrocław, Kraków, Gdańsk), there was no excess mortality at all (see Figure 2).

Figure 2: Excess mortality and excess revenues by municipality



Changes in personal revenues during COVID-19 reveal no obvious spatial pattern. Municipalities in which residents had revenues significantly below the expected values seem randomly spread across the country. Territories in the east seem more inclined to show revenues above the expectations.

OLS estimation (see Table 2) shows that excess mortality is higher in municipalities with older, less educated population, and these located further from the main regional cities. Proportion of ruling party supporters among voters is positively correlated with mortality. Also, we observe a conditional convergence of mortality during covid: Excess mortality is higher in places with relatively low mortality before the pandemic.

Table 2. OLS regression results

	(1)	(2)
	excess_mortality	excess_revenue
mortality_pre_covid	-0.399***	
	(0.0213)	
municipality_type (rural)	0.00483	-0.522
	(0.152)	(1.418)
municipality_type (mixed)	-0.174	0.367
	(0.148)	(1.384)
perc_vaccinated	-0.00636	0.0650
	(0.00629)	(0.0588)
log_income_pre_covid	-0.213	
	(0.266)	
perc_higher_edu	-0.0646***	0.264***
	(0.00879)	(0.0768)
Domnicantes	-0.0103***	-0.0641**
	(0.00329)	(0.0299)
election_turnover	-0.0183**	0.203***

	(0.00716)	(0.0658)
PiS_2019	0.00752**	-0.0353
	(0.00346)	(0.0314)
pop_density_pre_covid	-0.000149	0.0000798
	(0.000100)	(0.000940)
perc_retirement_pre_covid	0.359***	-0.144
	(0.0164)	(0.102)
tourist_beds_pre_covid	-0.000166	-0.00124
	(0.000151)	(0.00141)
local_clinics_pre_covid	0.000390	-0.0120
	(0.0111)	(0.104)
car_access_woj	0.00345***	0.00866
	(0.00122)	(0.0114)
Change_target_grants	-0.185	0.971
	(0.126)	(1.176)
Change_local_spending	-0.284***	-0.643
	(0.108)	(1.014)
share_agri_pre_covid	-0.000449	0.0660***
	(0.00159)	(0.0150)
Income_revenue_ratio_pre_covid	0.00458*	-0.212***
	(0.00251)	(0.0548)
log_revenues_pre_covid		-21.06***
		(1.946)
_cons	4.315	232.5***
	(2.749)	(24.09)
N	2477	2477
R ²	0.251	0.142

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

When it comes to the revenues, we also observe a conditional convergence: higher average revenues before the pandemic are associated with lower growth of revenues during COVID-19. Municipalities with higher proportion of educated and politically active population and higher share of agricultural land in the total area were better off during the pandemic. More entrepreneurial localities (higher income/revenue ratio) seem to be worse off. The level of extra public spending seems to have no effect on personal revenues of the residents.

Peripheral location was among factors aggravating the pandemic risk for population, at least from the medical perspective. Also, low education and low income of local residents hampered the resilience of local communities against COVID – both in terms of mortality and the change in personal revenues.

Compared to OLS, the results based on machine learning algorithms show slightly different order of variables' importance in explaining both excess mortality and revenues during COVID, but the main findings are similar (see Figures A1 and A2 in the Appendix).

6. Policy implications

Both in terms of mortality and revenues we observe an unconditional and conditional convergence across Polish municipalities during the pandemic. This is a welcomed result from the point of view of the cohesion concerns. COVID-19 time did not petrify the gap between different territories in Poland.

Local resilience against the pandemic clearly depends on the quality of public policies, but this refers mostly to the long-term policies, a to much less extent – to the activities took in reaction to the outbreak of COVID-19.

Education policy, which shapes a population's level of education, has an impact on both mortality reduction and the ability to stabilize or increase income. The more educated a local community was, the more resilient it proved to be.

In terms of the long-term transport policy, the quality of roads may have impacted the excess mortality in different municipalities as it determined the time needed to access the major city in the region (with its health infrastructure). In turn, the availability of local clinics proved insignificant.

The rate of vaccination had no direct effect on local mortality level during covid, at least when other important factors (such as demographic profile) were controlled. However, one reason for that may be strong nonlinearity of the vaccination/mortality relationship. The RF estimation suggests that the impact of vaccination on mortality becomes stronger starting from about 55% of local population vaccinated. This level was reached by only 2% of municipalities.

The level of locally funded public spending was negatively correlated with the excess mortality, which suggests that local policy efforts might have been helpful in mitigating the pandemic impact. In contrast, there is no effect of government grants on mortality. Public spending had no effect at all on the change in personal revenues during the pandemic.

Excess mortality was higher in the municipalities with higher proportion of government supporters. This may indicate that the government informational campaign encouraging vaccinations and respecting the preventive measures against covid was ineffective and insufficient.

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Annex

Figure A1: Relationship between selected independent variables and excess mortality according to linear model, SVR and RF

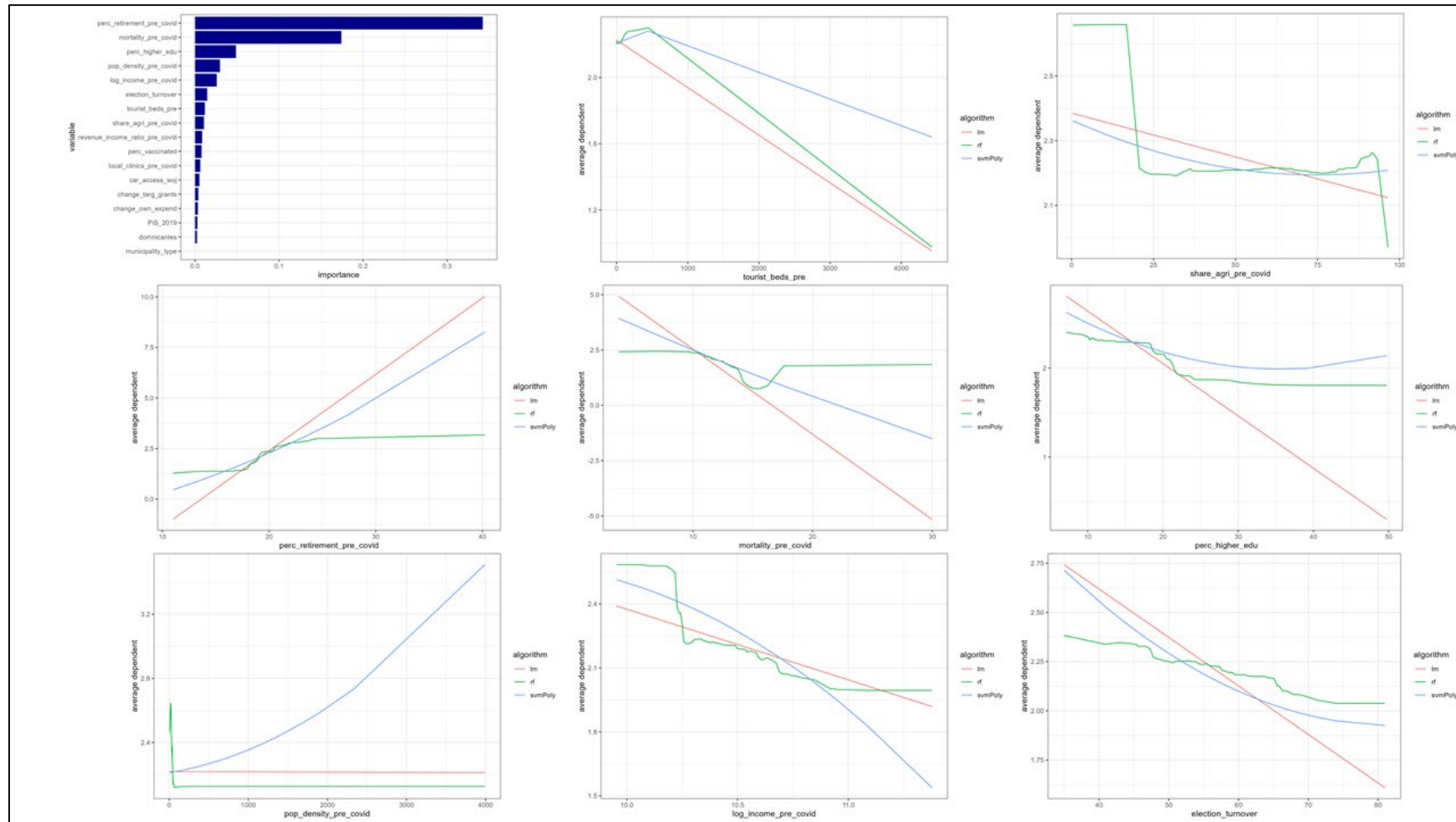


Figure A2: Relationship between selected independent variables and excess revenue according to linear model, SVR and RF

