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THE IMPACTS OF PUBLIC FINANCING ON THE GDP OF THE MUNICIPALITIES OF THE NORTH, NORTHEAST, AND MIDWEST OF BRAZIL° ¥

O IMPACTO DO FINANCIAMENTO PÚBLICO SOBRE O PIB DOS MUNICÍPIOS DO NORTE, NORDESTE E CENTRO-OESTE DO BRASIL

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Abstract

This article analyzed the effects of the disbursements from the Constitutional Financing Funds on the level and growth of the GDP of the municipalities of the North, Northeast, and Midwest regions of Brazil. We used spatial econometrics to identify possible evidence of spatial and temporal spillovers. The models were selected using Moran's I test for the residuals of the regressions, followed by Lagrange Multiplier tests—robust LM for spatial error and spatial-lag processes. The tests indicated that the SDEM model was appropriate for the regression analysis on the level and growth rates. The low values and the statistical significance of

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the coefficients suggest that the impacts are of minor importance, with no time or spatial spillovers.

Keywords: spatial analysis, constitutional financing funds, North, Northeast, Midwest, Brazil.
JEL codes: C0, R0, R150.

Resumo

Este artigo analisa os efeitos dos recursos distribuídos pelos Fundos Constitucionais sobre o nível e o crescimento do PIB dos municípios nas regiões Norte, Nordeste e Centro-Oeste do Brasil. Utilizamos modelos de econometria espacial para identificar possíveis evidências de transbordamentos espaciais e temporais. O processo de seleção indicou o modelo SDEM para a regressão em nível e para a taxa de crescimento. Os resultados mostram que os Fundos têm impacto positivo sobre o nível e taxas de crescimento do PIB dos municípios no período em análise.

Palavras-chave: análise espacial, fundos constitucionais, Norte, Nordeste, Centro-Oeste.
Classificação JEL: C0, R0, R150.

INTRODUCTION

The Constitutional Financing Funds (FCFs, as per the initials in Portuguese) were established to promote the lagging regions of the North, Northeast, and Midwest. From the beginning, the socioeconomic impacts of the resources were to be evaluated continuously, with a share of the resources devoted to this task. A series of studies were conducted on the effects on the GDP and the GDP growth of the municipalities (Almeida Júnior et al., 2007; da Silva et al., 2007; Cravo et al., 2014; Resende et al., 2017) or employment and wages (da Silva et al., 2009, Almeida Júnior et al., 2006; Cravo et al., 2014). However, the only investigation using econometric estimators is that of Resende et al. (2017). Given this, this article aims to analyze the impacts of the FCFs in a more recent period, applying appropriate spatial econometric techniques.

The article is structured as follows. In addition to the considerations of this introduction, Section 2 describes the creation of the FCFs, the origin of the resources, their operational dynamics, and the institutions eligible for credit. Section 3 reviews the empirical literature on the impacts of the FCFs on regional economic activities. Section 4 details the methodological procedures, and Section 5 provides the results. Lastly, Section 6 presents the final considerations and perspectives of new approaches.

I. FUNDING AND ALLOCATION CRITERIA

Law No. 7827 of 1989 created the FCFs to foster the economic development of the lagging regions of the North, Northeast, and Midwest, providing credit to their productive activities at below-market interest rates. In this sense, public banks are in charge of processing credit operations. The goal is to encourage production, income generation, entrepreneurship, local development, and productive regional integration under the Brazilian National Policy for Regional Development (PNDR, as per the initials in Portuguese). The idea is to reach areas lacking credit for productive activities, since private banks are not willing to finance them. Hence, this will positively influence the recovery of degraded areas, environmental conservation, and the development of sustainable activities. Half of the resources for the Northeast must be allocated to the semi-arid portion of the region. The institutional apparatus makes it clear that the main objective of issuing low-cost credit is to reduce internal and external economic disparities in the country and promote the economic sustainability of the regions.

The funding from the FCFs comes from 3% of the Income Tax and the Industrial Products Tax revenues, plus amortizations from previous operations and other sources, including contributions and donations from public and private, national or foreign institutions. As per the regulations, the Northeast must receive 60% of the resources and the other two regions, 20% each. The beneficiaries are private economic agents, including cooperatives and firms in agriculture, agro-industry, manufacturing, services, commerce, and mining. The objectives of the FCFs are to reduce inequalities within the benefitted areas and between regions in Brazil. There is explicit interest in encouraging collective productive activities and individual producers in various product segments.

The implementation of the FCFs must abide by the guidelines established by the credit-granting policies. The resources must prioritize activities facing survival difficulties, given the low economic dynamics of the regions. Among them, the mini, micro, and small rural producers and micro and small businesses are highlighted, preferably those that encourage the use of local raw materials and labor, including cooperatives and associations, and projects promoting the economic sustainability of the municipalities.

II. LITERATURE REVIEW

There are several evaluations of the FCFs involving the impacts on the labor market (da Silva et al., 2009; Soares et al., 2009; Resende, 2014) and the effects on the GDP of the municipalities (Soares et al., 2014; Cravo et al., 2014; Resende et al., 2017). Different analytical techniques have been used to identify the influence of the FCF resources on the benefited municipalities.

On the one hand, Almeida Júnior et al. (2006) were pioneers in grouping municipalities and trying to detect the effects of the FCFs between 1994 and 2005. They showed a concentration of the disbursements in dynamic municipalities and states. The Midwest received the large fraction, and areas with low Human Development Index, the lowest per capita values. The authors concluded that the disbursements follow credit demand, which is more robust in regions with better economic conditions, and suggested modifications in the allocation policy.

On the other hand, da Silva et al. (2009) used confidential data on individual loans. They applied the propensity score technique, composing a treatment group of firms receiving FCF resources between 2000 and 2003 and a control group of non-supported firms. The authors observed that only the Northeast FCFs (FNE, as per its initials in Portuguese) positively affected the rate of change of jobs generated, with no effect on the North FCFs (FNO, as per its initials in Portuguese) and the Midwest FCFs (FCO, as per its initials in Portuguese). The inability of firms in the Northeast to access credit from other sources is pointed out as a possible reason why the FNE positively impacted jobs in that region.

Furthermore, Cravo et al. (2014) studied the effects on GDP per capita in 2004-2010 with panel data and spatial econometric estimators. They found positive effects on regional economic growth but with no spillovers on other municipalities and micro-regions. In addition, Cravo et al. (2014) covered the same period, using panel data without controlling for spatial heterogeneity. They also identified positive impacts on GDP per capita growth. However, after controlling for spatial heterogeneity, the positive effects appeared at some spatial scales and regions without spillovers on neighboring municipalities. That is, the FCF resources influence the GDP per capita growth of the borrowing municipalities but do not affect that of their neighbors. Using panel data estimation, Resende et al. (2017) examined the period 1999-2011. Following a national regional development plan, they classified the municipalities into high-income, dynamic, low-income, and stagnant. Their results show positive impacts only on the GDP per capita growth of the dynamic and low-income municipalities. The spatial dependence analysis indicated that the indirect effects were more important than the direct ones, suggesting that productive integration extends beyond municipal and micro-regional borders. The difference in results compared to the previous works might be associated with the longer period studied.

III. METHODOLOGY

We analyzed the most recent period 2016-2019 and verified if the FCF disbursements between 2016 and 2018 influenced the level of GDP per capita in 2019 and its growth in the period. On theoretical grounds, the FCFs can be evaluatedas public investments, seeking to estimate their impacts on economic activity. Dall'erba and Le Gallo (2008) and Dall'erba and Fang (2017) indicated three possible lines of study. First, the neoclassical view suggests that the availability of resources benefits those regions where these are scarce, implying the convergence of short-term growth across regions. Second, the endogenous growth theory advocates that the increase in public investment is a mechanism for leveraging the marginal product of private capital, promoting wealth accumulation in the long term. Third, the new economic geography points to integration through infrastructure as a mechanism for boosting growth, even at different scales. However, in the empirical analysis of the impacts of the FCFs, all studies used the Beta-Convergence models of Barro et al. (1991).

a. Model

We started with the traditional ordinary least squares (OLS) approach, but the spatial data-generating process does not support the simplifying hypothesis of spatial non-heterogeneity. Therefore, we advanced by estimating the model with spatial lags of X, as Vega and Elhorst (2013, 2015) suggested. We then used the Lagrange multipliers (LM) tests to choose the model with the most parsimonious fit.

In the absence of spatial heterogeneity, we applied the models in Equations (1) and (2):

$$\ln Y_t = \beta_1 X_t + \varepsilon_t \tag{1}$$

$$DY_t = \beta X_t + \varepsilon_t \tag{2}$$

Where $\ln Y_t$ is a N x 1 containing the natural logarithm of GDP per capita of the municipalities in period *t* (dependent variable); β is a $K \times 1$ vector including the constant as well as the $(K - 1)$ coefficients of the independent variables, and X_t is an $(N \times K)$ matrix comprising all observations of the covariates; and ε_t is the error term. In Equation (2), $DY_t = (\ln Y_{t+n} - \ln Y_t)/n$ is the average annual GDP growth of the municipalities between the years t and $t + n$, where *n* is the number of years elapsed.

To check spatial heterogeneity, in Equation (3), we applied the general structure of a spatial model, as presented by Elhorst (2014):

$$DY_t = \rho W Y_t + X_t \beta + W X_t \delta + \varepsilon_t, \varepsilon_t = \lambda W \varepsilon_t + u_t \tag{2}$$

W is a line-normalized matrix of spatial weights with zeros on the main diagonal. We used a queen matrix[1], given the spatial configuration of the municipalities, with low urban conurbation, except for the metropolitan regions. This structure allows the correction of bias in the estimators, given by the omission of spatially correlated variables or spatial heterogeneity (LeSage & Pace, 2009).

1 Neighbors are municipalities sharing a territorial border. If i and j are contiguous, the variable takes value 1, otherwise 0. That is, we worked with first-order contiguity.

If $\delta = \lambda = 0$, it is appropriate to apply the spatial autocorrelation model (SAR); if $\delta = \rho = 0$, the spatial error model (SEM); and if $\delta = 0$, the spatial autoregressive model with autoregressive disturbances (SARAR). We also considered the cases in which only $\lambda = 0$ (spatial Durbin model - SDM) and $\rho = 0$ (spatial Durbin error model - SDEM), as suggested by Anselin and Bera (1998), Bivand et al. (2021), and Anselin (2022).

In addition, Moran's I tests (Appendix A and B) and LM tests were used to examine the presence of spatial autocorrelation in the residuals. Monte Carlo simulations were implemented to define the confidence intervals for Moran's I test (Appendix A and B). LM tests follow a chi-square distribution with degrees of freedom equal to the number of restricted spatial parameters (Anselin, 1988; Burridge, 1980; Gómez-Rubio et al., 2021; Anselin, 2022).

Furthermore, Florax et al. (2003) indicated a specific-to-general approach to select models, starting with testing the residuals of a non-spatial OLS model. On the other hand, Vega and Elhorst (2015) proposed testing the residuals of the SLX model as the first spatial model. We used a cross-sectional spatial equation for the 2019 GDP level (Tables 2 and 4) and for the GDP growth rate between 2016 and 2019 (Tables 2 and 6). The models were estimated by means of the statistical Software R (R Core Team, 2021), spatial-reg (Bivand et al., 2021).

b. Database

Table 1 presents the database, the description of the variables, the data sources, and the expected effects on the estimates. In the years analyzed, 2 711 municipalities of the three regions received FCF resources[2]. Data come from the National Bank for Economic and Social Development (BNDES, as per its initials in Portuguese), the Ministry of Regional Development (MDR, as per its initials in Portuguese), the Brazilian Institute of Geography and Statistics (IBGE, as per its initials in Portuguese), and the Annual Social Information Report (RAIS, as per its initials in Portuguese) from the Brazilian Ministry of Economy (MEB, as per its initials in Portuguese). The expected effects is that the disbursements of resources will positively influence the level and growth of GDP of the municipalities. Temporal and spatial spillovers and positive effects on the growth of jobs with university education are also expected. We used natural logarithms to obtain results in terms of elasticities.

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2 The municipalities of the North of Minas Gerais and Espírito Santo were excluded from the analysis. They are part of the area covered by the FNE but do not belong to the Northeast region.

Table 1. Database, description of the variables, sources, and expected results in the estimations

Variable	Description	Source	Expected Effect
Ln(GDPpc2019)	Natural logarithm of GDP per inhabitant in 2019	IBGE	
Ln(ΔGDP)	Natural logarithm of the growth rate of GDP between 2016-2019	IBGE	
Ln(CreditPub)	Total public credit from the BNDES and FCFs in the North, Northeast, and Midwest	BNDES-MDR	+
Ln(FCF)	FCFs in the North, Northeast, and Midwest total	MDR	+
Ln(BNDES)	Public credit from the BNDES total	BNDES	+
Ln(FNO)	Resources allocated and transferred by the FCFs in the North in 2016-2018	MDR	+
Ln(FNE)	Resources allocated and transferred by the FCFs in the Northeast in 2016-2018	MDR	+
Ln(FCO)	Resources allocated and transferred by the FCFs in the Midwest in 2016-2018	MDR	+
Ln(BNDES)	Resources allocated and transferred by the BNDES in 2016-2018	BNDES	+
Ln(UnivEdu18)	Formal workers with complete higher education	RAIS-MEB	+

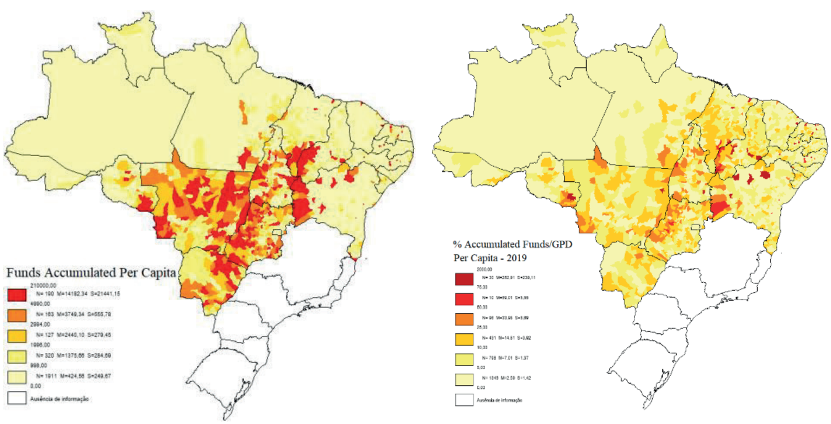
Source: Elaboration by the authors.

III. RESULTS AND DISCUSSIONS

a. Moran's I tests and statistics

The maps in Figure 1 show the accumulated per capita values of FCF disbursements between 2006 and 2018 in minimum wage ranges (map on the left) and the ratio of the accumulated disbursements in the period in the GDP per capita in 2019. A total of 1 911 municipalities received three-year accumulated amounts up to one minimum wage. That is, 70.5% of the municipalities registered an average transfer of R$ 424.56 per capita in the period, which is a low amount to finance productive activities. Only 190 municipalities (7%) recorded per capita accumulated values of more than five minimum wages. The municipalities of the Midwest and some of the MATOPIBA (the grain-producing region of the country) obtained the largest loans. On the other hand, the lowest amounts were assigned to most of the municipalities of the North and Northeast. The map on the right in Figure 1 shows the percentage participation of accumulated FCF resources over the GDP per capita in 2019. It evidences that 49.6% of the municipalities collected from 0 to 5% of their 2019 GDP per capita, whereas only 30 municipalities (1.1%) registered more than 75%. Thus, the participation of FCF resources is low in most of the municipalities, anticipating minor impacts on the local economies.

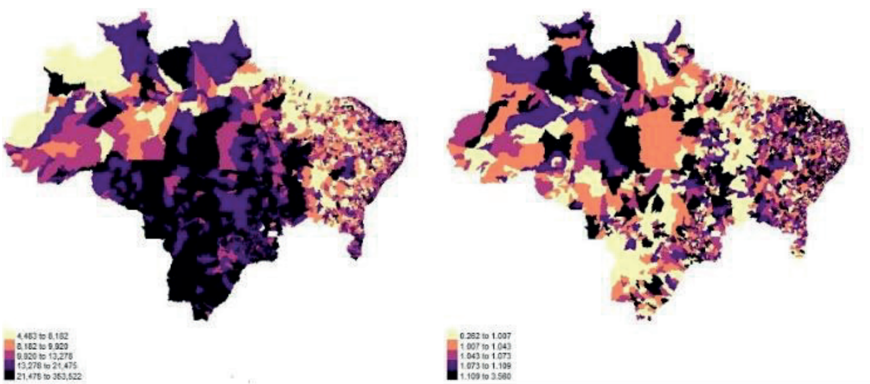
Figure 1. Spatial distribution of the FCFs (2016-2018)



Source: Elaboration by the authors based on the results.

The map on the left in Figure 2 reveals the spatial pattern of GDP *per capita* in 2019, indicating higher values in the municipalities of the Midwest region, resulting from their outstanding importance in Brazilian agribusiness activity (de Souza Junior et al., 2020). In the Northeast, the state capitals along the coast and the municipalities of the MATOPIBA stand out (Ribeiro et al., 2020). This latter region is new in agribusiness activity, especially in soybean and corn (Bolfe *et al*., 2016). *The watered areas of the* São Francisco river valley, an irrigated fruit-growing region destined for export, are also *outliers*. The semi-arid region and the north of Maranhão concentrate the municipalities with the lowest GDP *per capita.* The map on the right exhibits the GDP growth rates, with no particular spatial pattern.

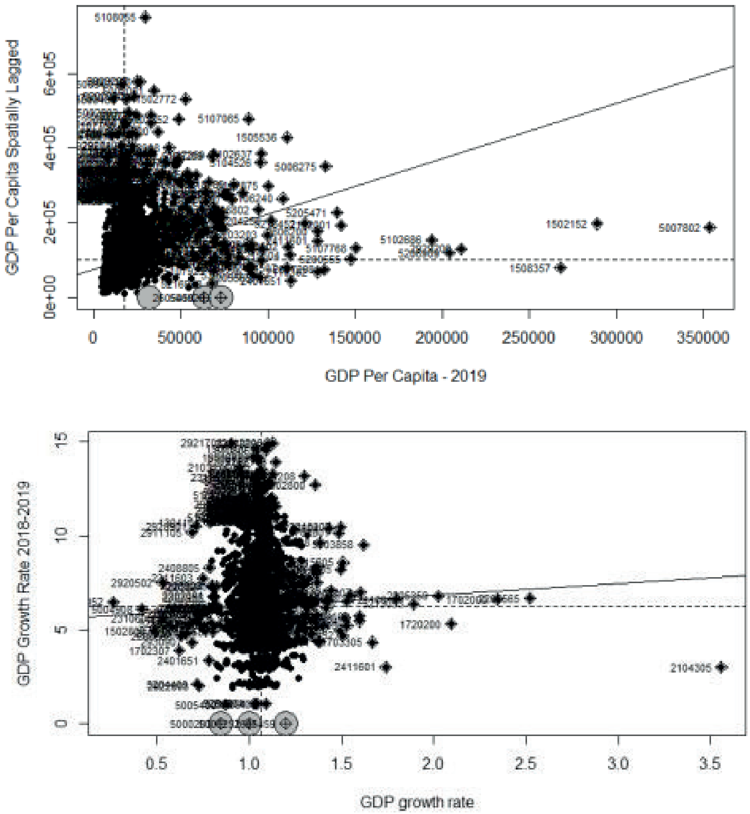
Figure 2. GDP per capita and GDP growth rates



Source: Elaboration by the authors based on the results.

Figure 3 shows Moran's I diagrams for the GDP *per capita* of the municipalities. The left panel indicates a slight positive association between the level of GDP per capita of a municipality in 2019 and the levels of its neighbors in the same year. The right panel shows the relationship between the growth rate of a municipality and those of its neighbors. No specific pattern is observed; there is a large dispersion of rates in the neighbors, regardless of the level in the municipality of reference.

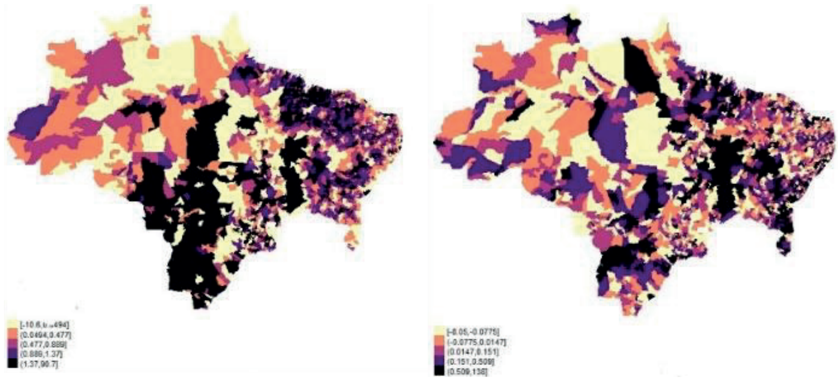
Figure 3. GDP per capita and GDP growth: spatial patterns



Source: Elaboration by the authors based on the results.

The map on the left in Figure 4 shows a concentration pattern of municipalities with GDP levels similar to their neighbors. However, the map in the right panel evidences a more dispersed pattern, with high and low growth rates in neighboring municipalities.

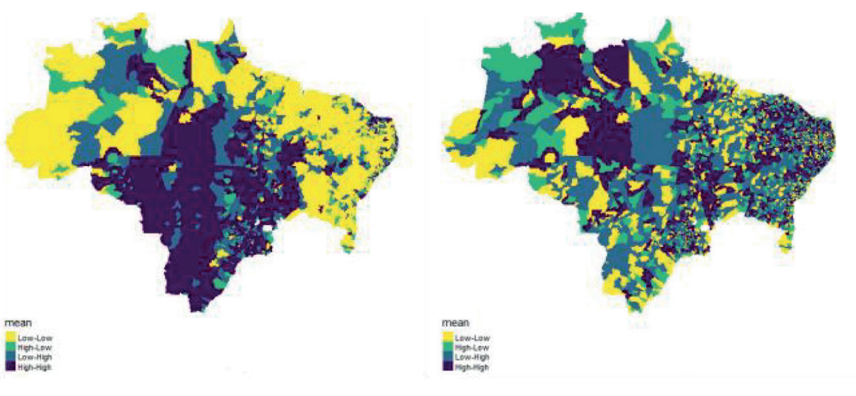
Figure 4. Local Moran's I for GDP per capita and GDP growth



Source: Elaboration by the authors based on the results.

Figure 5 presents the Local Moran's I *clusters* for the GDP growth levels and growth rates. As for GDP, the map on the left indicates that the concentration patterns are associated with the development levels of these municipalities. The high-high quadrant includes the municipalities of the MATOPIBA and the Midwest, for the most part, where agribusiness predominates. The low-low quadrant comprises municipalities of the semi-arid Northeast and part of the North, regions with the lowest economic dynamism. As for growth rates (right panel), no pattern emerges.

Figure 5. Local Moran's I clusters



Source: elaboration by the authors based on the results.

b. Results

Below, Table 2 presents the OLS results. Besides the FCF disbursements, we included the loans from the BNDES as a control variable, an important source of public funding, although focused on large-scale operations. We also considered the number of workers with university education in the municipality to take into account the heterogeneity of the municipalities. The negative coefficient in the first column indicates that the 2016-2018 accumulated disbursements from the FCFs and BNDES together (PubCredit) negatively influenced the GDP growth rate, with a low coefficient and low significance, but had a positive and significant effect on the GDP per capita levels in 2019. When estimated separately (3rd and 4th columns), neither form of financing affected GDP growth rates (3rd column). However, they were positive and significant in explaining the GDP levels of the municipalities in 2019.

Table 2. OLS Estimation

Variables	Dependent variable:			
	Ln(Δ%GDP)	Ln(GDPpc2019)	Ln(Δ%GDP)	Ln(GDPpc2019)
Ln(PubCredit)	-0.002 *	0.182 ***		
	(0.001)	(0.007)		
Ln(FCF)			-0.001	0.122 ***
			(0.001)	(0.007)
Ln(BNDES)			-0.001	0.037 ***
			(0.0005)	(0.002)
Constant	0.094 ***	6.596 ***	0.086 ***	7.091 ***
	(0.020)	(0.107)	(0.021)	(0.107)
# Obsv.	2 711	2 711	2 711	2 711
R^2	0.001	0.217	0.002	0.280
Adjusted R^2	0.001	0.217	0.001	0.279
Residuals Std. Error	0.104	0.547	0.104	0.525)
F Statistic	3 538 *	750 476 ***	2 448 *	525 534 ***

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

Source: Elaboration by the authors based on the estimation results.

Table 3 shows problems in the residuals of the OLS regression of GDP levels, revealed by the diagnostic tests for spatial correlation. The LM and Robust LM tests indicated the SDEM model as the preferred specification (Anselin & Bera, 1998; Florax et al., 2003). Therefore, we used this model in the following estimations.

Table 3. Spatial correlation tests

OLS			SLX		
LMer = 763.68	df=1	p-value< 2.2e-16	LMer = 704.82	df=1	p-value < 2.2e-16
LMlag = 249.62	df=1	p-value < 2.2e-16	LMlag = 351.5	df = 1	p-value < 2.2e-16
RLMerr = 515.28	df=1	p-value < 2.2e-16	RLMerr = 359.61	df = 1	p-value < 2.2e-16
RLMlag = 1.2212	df=1	p-value = 0.2691	RLMlag = 6.2905	df = 1	p-value = 0.01214

Source: Elaboration by the authors based on the estimation results.

In Table 4, we present the results of the effects of disbursements on GDP levels in 2019 in each region, year by year, to capture possible time spillovers. The results of interest are in columns V (effects on the municipality that received the resources) and VI (effects on neighboring municipalities). The FNO loans disbursed in 2018 were the only ones with positive and significant impacts on the municipality that received the loans, and the disbursements of 2017 only had effects on neighboring municipalities. An increase of one percentage point in the FNO resources allocated to a municipality in 2018 had an impact of 3.5 percentage points on its 2019 GDP level, with no effect on neighboring municipalities. For the 2017 disbursements, the impact is positive only in neighboring municipalities. These results are in line with those obtained by Cravo et al. (2014).

Concerning the Northeast region (FNE resources), the 2016 disbursements had negative effects on the GDP of the municipalities, especially on the neighbors. However, the disbursements of 2017 and 2018 were positively related to the 2019 GDP levels of the receiving municipalities and their neighbors. In the Midwest region (FCO), the effects were positive for the 2016 and 2018 disbursements but limited to the receiving municipalities. These results coincide with those of Resende et al. (2017). Although we are not interested in the BNDES loans, which are only controls in assessing the influence of the FCFs, it is worth noting that their effects are positive. Still, the elasticities are small, showing no spillovers on neighboring municipalities.

Table 4. Impacts on the 2019 GDP levels

Variables	Dependent variable: Ln(GDPpc2019)						
	OLS	SLX Ln	SLX, lag	Spatial Auto-regressive	SDEM	SDEM, lag	Spatial Error
	I	II	III	IV	V	VI	VII
Ln(FNO16)	0.003	0.003	-0.064***	0.005	0.006	-0.033	0.009
	(0.008)	(0.008)	(0.019)	(0.007)	(0.007)	(0.022)	(0.006)
Ln(FNO17)	0.007	0.005	0.035***	0.004	0.007	0.037**	0.002
	(0.006)	(0.007)	(0.013)	(0.006)	(0.006)	(0.016)	(0.006)
Ln(FNO18)	0.060***	0.043***	0.029	0.051***	0.035***	-0.015	0.049***
	(0.011)	(0.011)	(0.021)	(0.010)	(0.010)	(0.024)	(0.010)
Ln(FNE16)	-0.037**	-0.021	-0.168***	-0.037**	-0.028*	-0.155***	-0.016
	(0.016)	(0.016)	(0.036)	(0.015)	(0.015)	(0.040)	(0.014)
Ln(FNE17)	0.046***	0.048***	-0.027	0.043***	0.049***	0.005	0.043***
	(0.016)	(0.016)	(0.037)	(0.015)	(0.015)	(0.041)	(0.013)
Ln(FNE18)	0.039***	0.031**	0.165***	0.037***	0.030**	0.111***	0.015
	(0.013)	(0.013)	(0.029)	(0.012)	(0.012)	(0.033)	(0.011)
Ln(FCO16)	-0.076***	-0.075***	-0.070	-0.077***	-0.076***	-0.019	-0.073***
	(0.020)	(0.020)	(0.047)	(0.020)	(0.019)	(0.054)	(0.018)
Ln(FCO17)	0.015	0.002	0.014	-0.037	0.008	-0.055	0.019
	(0.038)	(0.039)	(0.084)	(0.036)	(0.037)	(0.094)	(0.032)
Ln(FCO18)	0.155***	0.157***	0.045	0.192***	0.152***	0.050	0.144***
	(0.034)	(0.034)	(0.077)	(0.033)	(0.033)	(0.086)	(0.029)
Ln(BNDES16)	0.007***	0.005**	0.020***	0.006***	0.005**	0.009	0.004**
	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.006)	(0.002)
Ln(BNDES17)	0.003	0.003	-0.006	0.003	0.003	-0.001	0.004*
	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.006)	(0.002)
Ln(BNDES18)	0.011***	0.009***	0.007	0.009***	0.009***	0.007	0.009***
	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.005)	(0.002)
Ln(UnivEdu18)	0.046***	0.052***	-0.034**	0.050***	0.054***	-0.013	0.057***
	(0.008)	(0.010)	(0.015)	(0.008)	(0.008)	(0.019)	(0.008)
Constant	8.147***	8.355***		5.905***	8.547***		8.231***
	(0.088)	(0.151)		(0.182)	(0.186)		(0.083)

# Obsv	2 711	2 711	2 711	2 711	2 711
R^2	0.487	0.504			
Adjusted R^2	0.485	0.499			
Ln Likelihood			-1 530 421	-1 336 533	-1 359 519
$Sigma^2$			0.179	0.148	0.150
Akaike Inf. Crit.			3 092 842	2 731 066	2 751 039
Residual Std. Error	0.444 (df = 2697)	0.438 (df = 2684)			
F Statistic	197 298*** (df = 13; 2697)	104 718*** (df = 26; 2684)			
Wald Test (df = 1)			192 090***	599 586***	653 449***
LR Test (df = 1)			211 424***	512 513***	553 227***
Note: *p=0.1; **p=0.05; ***p<0.01.					

Source: elaboration by the authors based on the estimation results.

Below, we present the assessment of the impacts on GDP growth rates. Table 5 provides the results for the model selection criteria, which led to the choice of the SDEM as the most appropriate for correcting the spatial problems, since the RLMerr was the highest value (Anselin & Bera, 1998).

Table 5. LM test for OLS and SLX models

OLS VAR			SLX VAR		
L Merr = 77 907	df=1	p-value < 2.2e-16	LMer = 58 889	df=1	p-value = 1.665e-14
LMlag = 61 899	df=1	p-value = 3.664e-15	LMlag = 57 399	df=1	p-value = 3.553e-14
RLMerr = 50 627	df=1	p-value = 1.117e-12	RLMerr = 1 532	df=1	p-value = 0.2158
RLMlag = 34 619	df=1	p-value = 4.01e-09	RLMlag = 0.041916	df=1	p-value = 0.8378

Source: elaboration by the authors based on the estimation results.

Columns V and VI of Table 6 contain the results of interest. In this case, we included the GDP per capita level of 2018 as an additional control to take care of the different GDP per capita levels of the municipalities. In the North region (FNO), only the disbursements of 2018 had a positive and significant impact on GDP per capita growth of the period. Still, the influence on the neighbors was negative and significant. In the Northeast region (FNE), the impacts on the municipalities that received the loans did not significantly affect the growth rate of their GDP per capita. However, they influenced the neighbors in 2016 (negatively) and 2018 (positively). The same situation of no significant effects on the municipality receiving the disbursements occurred in the Midwest region (FCO), and the influence on the neighbors was significant for the disbursements of 2016 (positive) and 2018 (negative). A comparison of the OLS results in column I with those in columns V and VI illustrates the advantages of considering the possible spatial spillovers of the loans in assessing the impacts. The OLS estimation shows no effects on growth, while the SDEM models, besides pointing out the impacts on the neighbors, indicate situations in which these are significant.

Table 6: Impacts on the 2016-2019 GDP growth

Variables	Dependent variable: Ln(ΔGDP)						
	OLS	SLX	SLX, Lag	Spatial Auto-regressive	SDEM	SDEM, Lag	Spatial Error
	I	II	III	IV	V	VI	VII
Ln(GDPpc18)	-0.034***	-0.043***	0.033***	-0.035***	-0.046***	0.030 ***	-0.043***
	(0.004)	(0.005)	(0.006)	(0.004)	(0.005)	(0.006)	(0.005)
Ln(FNO16)	-0.002	-0.002	-0.001	-0.002	-0.002	-0.001	-0.002
	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.005)	(0.002)
Ln(FNO17)	0.002	0.001	0.002	0.002	0.002	0.002	0.001
	(0.001)	(0.002)	(0.003)	(0.001)	(0.002)	(0.003)	(0.002)
Ln(FNO18)	0.003	0.007 **	-0.013 **	0.003	0.006 **	-0.012 **	0.004
	(0.002)	(0.003)	(0.005)	(0.002)	(0.003)	(0.006)	(0.002)
Ln(FNE16)	-0.002	-0.002	-0.024 ***	-0.001	-0.002	-0.028 ***	0.0005
	(0.004)	(0.004)	(0.008)	(0.004)	(0.004)	(0.009)	(0.004)
Ln(FNE17)	-0.0002	-0.001	0.002	-0.0003	-0.001	0.005	-0.0004
	(0.004)	(0.004)	(0.009)	(0.004)	(0.004)	(0.009)	(0.004)
Ln(FNE18)	0.004	0.002	0.017 **	0.003	0.002	0.018 **	0.002
	(0.003)	(0.003)	(0.007)	(0.003)	(0.003)	(0.007)	(0.003)
Ln(FCO16)	-0.001	-0.004	0.034***	-0.002	-0.003	0.031***	-0.004
	(0.005)	(0.005)	(0.011)	(0.005)	(0.005)	(0.012)	(0.005)
Ln(FCO17)	0.006	0.006	-0.008	0.006	0.005	-0.007	0.006
	(0.009)	(0.009)	(0.020)	(0.009)	(0.009)	(0.021)	(0.008)

Ln(FCO18)	-0.002	0.003	-0.035*	0.0001	0.003	-0.033*	0.002
	(0.008)	(0.008)	(0.018)	(0.008)	(0.008)	(0.019)	(0.008)
Ln(BNDES16)	0.001	0.001	0.002 *	0.001	0.001	0.002	0.0005
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Ln(BNDES17)	-0.001**	-0.001*	-0.001	-0.001**	-0.001*	-0.0002	-0.001**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Ln(BNDES18)	0.0002	0.0004	-0.001	0.0003	0.0004	-0.001	0.0004
	(0.0005)	(0.0005)	(0.001)	(0.0005)	(0.0005)	(0.001)	(0.0005)
Ln(UnivEdu18)	0.002	0.005**	-0.010***	0.002	0.005**	-0.009**	0.004*
	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.004)	(0.002)
Constant	0.336***	0.243***		0.329***	0.296 ***		0.399***
	(0.041)	(0.056)		(0.041)	(0.061)		(0.043)
# Observ.	2 711	2 711		2 711	2 711		2 711
R 2	0.029	0.055					
Adjusted R2	0.024	0.046					
Ln Likelihood				2 359 431	2 395 291		2 367 607
Sigma 2				0.010	0.010		0.010
Akaike Inf. Crit.				-4 684 861	-4 728 582		-4 701 215
Resid Std Error	0.103 (df=2696)	0.102 (df=2682)					
F Statistic	5 848*** (df=14; 2696)	5 620*** (df=28; 2682)					
Wald Test (df=1)				56 585 ***	55 544 ***		77 045 ***
LR Test (df = 1)				55 018 ***	53 273 ***		71 372 ***
Note: *p=0.1; **p=0.05; ***p<0.01.							

Source: elaboration by the authors based on the estimation results.

FINAL CONSIDERATIONS

The objective of this article was to analyze the impacts of the FCF resources in the North, Northeast, and Midwest on the GDP per capita growth of the municipalities between 2016 and 2019, as well as on the GDP per capita levels of the municipalities in 2019. We used spatial regressions to capture the effect of covariates on the dependent variable. We applied the LMerr and LMlag tests and the robust tests RLMerr and RLMlag, which indicated the SDEM model as the preferred one.

The results evidence that the FCF resources had some influence on the GDP per capita and its growth in the years under observation. However, the effects of the FCFs are sporadic in time without temporal spillovers. Furthermore, the low coefficients and their low statistical significance suggest that the impacts are of minor importance. The influence of the FCFs on the economic activities of the benefited regions is limited to the year of the disbursements, with no effects over time. This lack of influence might be related to the type of activity and economic agent supported, typically small properties. Thus, a task for future research is considering the sectoral destination of the resources.

Another conclusion of this study is that the effects of the loans are circumscribed to the receiving municipality, with few spillovers on neighboring areas, with few exceptions. This indicates that the FCF program has not reached the goal of promoting the integration of economic activities in the lagging regions of the North, Northeast, and Midwest. The modest effects, although positive when significant, evidence that the FCF program is far from modifying the economic structure of the targeted regions.

APPENDIX

A: Moran's I test under randomization and Moran's I Monte Carlo Simulation for level estimations

Model	OLS Level	SLX Level	SAR Level	SDEM Level	NO Level
Moran's I statistic st dev	27 695	26 605	13 441	-2 498	-2.6339
p-value	2.20E-16	2.20E-16	2.20E-16	0.9938	0.9958
Moran's I Monte Carlo Simulation					
Model	OLS Level	SLX Level	SAR Level	SDEM Level	NO Level
Statistic	0.31879	0.31879	0.1544	-0.02915	-0.03071
p-value	0.001	0.001	0.001	0.992	0.995

Source: elaboration by the authors based on the estimation results.

B: Moran’s I test under randomization and Moran’s I Monte Carlo Simulation for growing estimates

Models	OLS Growth	SLX Growth	Growth SAR	SDEM Growth	NO GROWTH
Moran’s I st dev	8.9067	7.7463	8.9067	-0.49291	-0.70991
p-value	2.20E-16	4.73E-15	2.20E-16	0.689	0.7611
Moran’s I Monte Carlo Simulation					
Models	OLS Growth	SLX Growth	Growth SAR	SDEM Growth	NO GROWTH
statistic	0.10182	0.088524	0.005568	-0.00602	-0.00851
p-value	0.001	0.001	0.272	0.689	0.762

Source: elaboration by the authors based on the estimation results.

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