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DIGITALIZATION OF ROMANIAN PUBLIC ADMINISTRATION: A PANEL DATA ANALYSIS AT REGIONAL LEVEL

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Abstract. Digital transformation of public administration creates opportunities for transparency, accountability, efficiency, and better tax collection. Benefits are even more critical considering the coronavirus crisis when millions of people worldwide engage in online solutions. Our research paper offers clear insights into the public administrations' strategic management when it comes to the impact of digitalization upon local tax revenues collection. In this setting, we investigate the effects of the digitalization of the Romanian public sector, focusing on local tax revenues collection covering the period 2015–2021. The data was collected from the national platform for e-payments – *ghiseul.ro*. To assess the impact of digitalization, we opted for the panel data analysis, complemented by reliability and robustness tests. The local tax revenues are settled as the dependent variable and analysed in relationship with the number of payments made via the above-mentioned platform (assigned as a proxy for digitalization). Gross domestic product per capita, Unemployment rate, and Average net earnings are control variables. Our outcomes show that digitalization impacts local tax revenues, but it differs across the country, the highest impact being registered in the case of macro-region 3. All independent variables are statistically significant, leading to the assumption that the empirical model is accurate.

Keywords: digitalization, local tax revenue, public administration, Romania, panel data analysis, tax collection, tax compliance, Covid-19.

JEL Classification: C23, H71, R11, O33.

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Introduction

Recently, digital tax collection is the main point of national and international discussions on public revenues. Once its specific costs have been amortized, digitalization profits not only to the government but also to the citizens (Carter & Bélanger, 2005; Belanger & Hiller, 2006). Nonetheless, the subject of digital taxation has not been studied enough in the literature (Fischer et al., 2021; Olbert & Spengel, 2019).

Direct benefits for the government are a boosted collection of taxes, increased transparency, decreased tax evasion, and the ability to offer improved services to taxpayers. The taxpayer will have lower costs to comply, better services received (in terms of quality, speed, and diversity) from the public authorities, less bureaucracy, greater public access to information, and a perceived easier way to comply. All these benefits reported for the citizens are drivers to better voluntary compliance.

Nevertheless, digitalization may improve tax enforcement technology by collecting higher levels of public resources and more reliable information on the economic outcomes of taxpayers. It also improves the equity-efficiency trade-off by implementing more complex tax systems to target better revenues redistribution.

Currently, digital transformation is considered the critical driver of change in governments as their goals are to improve transparency, accountability, tax collection, and efficiency, given that e-government can facilitate integrated policies and public services for all participants on the market (Burlacu et al., 2021). Digitalization offers the potential of reshaping the public sector activities and processes, building better relationships between citizens and the government (Ndou, 2004), enhancing transparency, increasing efficiencies in processes by allowing information sharing across government departments, contributing to the elimination of mistakes from manual procedures, decreasing the required time for transactions (Kuldosheva, 2021). It also represents a paradigm shift in public services delivery (Ho, 2002), especially in time of Covid-19 pandemic.

Thus, digitalization of public administration may be considered a powerful instrument to boost citizen-government interaction (Im et al., 2014) or to modernize the public administration (United Nations, 2014). Also, it helps decrease tax evasion and tax avoidance by increasing the transparency of the actual economic outcomes of the taxpayers (Devereux & Vella, 2017; Jacobs, 2017).

Research concerning the potential and political implications of digitalization of public administration is triggered by the growing interest of the public sector in Information and Communication Technology- ICT (Welch et al., 2005; Yang & Rho, 2007). The public sector estimates that digitalization can offer a possibility for enhancing public service delivery while, at the same time, increasing productivity in the public sector and boosting tax collection. Jingnan et al. (2017) found that digitalization will make tax collection more efficient for the government and the taxpayer.

Previous researchers acknowledge the role the ease of the tax system plays in tax conformity and, as a result, in tax collection. In its handbook on simplifying the tax system, the World Bank Group (2009) states that the means and timing of payment must be convenient to the payer.

The more inconvenient the means of payment, the higher the compliance costs (Jenkins & Forlemu, 1993; Fanea-Ivanovici et al., 2019). The time spent for filing and paying taxes by taxpayers and their unpaid helpers is one of the Tax Compliance Costs' Components (Tran-Nam et al., 2020); digitalization decreases the time needed to comply; therefore, the tax compliance costs are lower when the public authorities offer the e-services.

Carter and Bélanger (2005) define e-government as the "use of information technology to enable and improve the efficiency with which government services are provided to citizens, employees, businesses, and agencies." The electronic reporting of taxes to authorities (e-filing) and electronic payments (e-payment), allowing the tracing of tax revenues for any transaction's occurrence to taxpayers and even third parties, are considered the best way to mitigate tax evasion. Thus, by significantly reducing the use of cash, digitalization can also help diminish the size of shadow economies and, hence, opportunities for tax evasion (Rogoff, 2016; Nimer et al., 2022).

Hanrahan (2021) examines the effect of the advancement of digitalization on tax revenues employing both static and dynamic panel data analysis techniques on a set of data covering OECD countries during the period from 1995 to 2018. The author concludes that digitalization may harm the ability of a country with high digital dynamics to generate higher tax returns.

By contrast, in emerging countries, a large share of government payment transactions to and from individuals and businesses and between government entities are performed in cash or by check when payments are measured by volume or the number of transactions (Lund et al., 2017).

Traditionally, in Romania, local taxes were paid through the local public administration offices or the post offices. Local taxes are relevant for our research as they are owed by most Romanian citizens owning houses, land, or vehicles. The transactions were done mainly with cash and, usually, after the local tax authorities issued a tax decision. To make matters worse, different public authorities charged different taxes, so the taxpayer had to comply with multiple rules and visit multiple offices to make the payments. This situation was not uncommon for other eastern European countries as well (Gombar et al., 2022).

Moreover, despite domestic legislation trying to limit cash usage, tax authorities equipped their offices with POS (Point-of-Sale) terminals needed to collect taxes through a bank account and not in cash only a couple of years ago.

This situation slowly changed when a national platform emerged on the market and developed to integrate more e-services and ease interaction with public authorities.

The first national centralized platform that allowed citizens to pay their tax remotely without visiting an administrative office is the National Electronic Payment System, known as *ghiseul.ro* (Ghiseul.ro, 2022).

At the beginning of the Pandemic Covid-19, meaning the year of 2020, the tax collection dropped in Romania. Paying taxes meant visiting the tax authority to fill out some forms and use cash. The crisis changed this dynamic as restrictions were imposed to limit in-person interaction and cash usage. Therefore, digital transformation (understood as not only a digitalization of the processes, but as a more comprehensive institutional change (Fischer et al., 2021)) of the tax collection system became a must (Țibulcă, 2021). The drastic change in the

digitalization process was a common characteristic for many tax administrations worldwide (OECD, 2021) which shifted fast to offering e-services to their taxpayers.

The perceived ease of use observed by the taxpayers was validated by the effortless ways to enroll in the system, the possibility the pay the taxes without going to the tax office – sometimes not even in the same city as the taxpayer, the existence of the proof for the paid tax, the possibility to pay even if not vaccinated (the law imposed restrictions), fewer costs incurred in the process of e-payment (such as no bank fee and no traveling costs), more convenient (as no queue time nor being exposed to the attitude of the public officer) and others.

The collection costs for the tax authorities decreased as well, as the payments were registered automatically and not manually as before (with a lower rate of errors happening), fewer costs associated with dealing with cash, fewer cases of frauds, and others, as well.

The limited previous research addressing the topic of digitalization at the national level and its determinants represents a gap that needs to be filled. In this context, the hypothesis we intend to examine is:

RQ: *Is there a significant impact of digitalization on local tax collection, considering some of the economic traits of different macro-regions in Romania?*

To test the hypothesis, we structured the rest of the paper as follows: the next section describes the methods and the data used in our research paper, the results section will point out both the main outcomes of data analysis but also their interpretation from the perspective of earlier studies and the conclusion section will create the background for future research in the field of digitalization of public administration.

1. Data description and methodology

1.1. Data description

Local budgets represent a financial-budgetary policy instrument through which the state can intervene in the economy at the level of local communities. At the same time, this instrument impacts the results of the general consolidated budget. The local budget's revenues are the second primary source of public revenues in Romania, after the state's budget revenues, for the central government level. For the analyzed period (2015–2021), on average, in Romania (Ministry of Finance, 2022), local budgets revenues represent 28.26% out the total public revenues collected at the central level. Furthermore, through the local budgets, an average of 3.38% of total taxation has been collected at the national level in Romania (European Commission, 2021). Local taxes refer to taxes levied mainly upon immovable property (land and buildings) and means of transportation. Romania (European Commission, 2022b) has the highest homeownership rate amidst member states (96.1% in 2021 as compared to a European average of approximately 70%) and an average of 307.2 passengers' cars per 1 000 inhabitants in the analyzed period (European Commission, 2022c). As the total number of dwellings was in 2021, over 9 million (National Institute of Statistics, 2020), we believe that the local tax is one of the most frequent tax duties for Romanian citizens, even if its level is lower than the European average. In Romania, more and more individuals use the internet, a trend also reflected by the percentage of households with internet access, which increased from 68% in 2015 to 89% in 2021 (European Commission, 2022a). Furthermore, we found

that the percentage of individuals that have used the internet in the last 12 months has increased from 62% in 2015 to 88% in 2021 (26 percentage points), meaning an average of 75.43% for the period 2015–2021 (European Commission, 2022a) and, in average, 52.42% of individuals are using daily the internet. Thus, for the Romanian taxpayers, subjects to local taxes, it is becoming increasingly easy to pay the taxes from the comfort of their house, considering that most people have access to the internet from home.

Our data was collected from the national platform *ghiseul.ro*. This was the first platform that allowed citizens to pay their taxes remotely without visiting an administrative office. Ten years after the launch, in 2021, a larger part of the Romanian public administration became more digitalized. At the end of January 2022, more than 1.25 million users were reported, and in March 2022, the platform had 1.35 million users enrolled (Ghiseul.ro, 2022).

As the legislation imposed no sanctions on the local authorities that failed to enroll in the platform, many local authorities decided just to preserve the old way of collecting taxes. Some of them developed their own platforms, and some chose to enroll, nevertheless, in the platform. However, considering that *ghiseul.ro* was endorsed by the central fiscal authorities and many local authorities, we strongly believe that the taxes collected through this platform are significantly higher than the tax collected from the few existing local platforms.

We analyze the impact of digitalization (the number of payments of local taxes processed through ghiseul.ro was used as a proxy for digitalization) on local tax revenues using the following control variable: Gross Domestic Product per capita, Unemployment rate and, Average net earnings. Table 1 presents the list of the used variables in our empirical analysis. As previous research shows (Carter & Bélanger, 2005; Hiller & Belanger, 2001), e-payments availability is one example of services that could be offered by the public authority in their effort to digitalize. In Romania, most of the active force is employed, so they don't have to pay by themselves income tax, but they owe local taxes for houses, land, or vehicles. That's why

Table 1. Variables included in the panel data

Variables	Description	Formulation	Source
Local_Tax	Local tax revenues*	Expressed in national currency	Ministry of Development, Public Works and Administration (2022)
Pay	Payments of local taxes processed through ghiseul.ro	Expressed as a number of payments	Ghiseul.ro (2022)
GDPpc	Gross domestic product per capita	Expressed in EUR	Eurostat and National Commission for Strategy and Prognosis (2022)
Unemployment	Unemployment rate	Expressed as % of unemployment in active population	National Institute of Statistics (2022) and National Commission for Strategy and Prognosis (2022)
Anet_E	Average net earnings	Expressed in national currency	National Institute of Statistics and National (2022) Commission for Strategy and Prognosis (2022)

Note: * Local tax revenues refer to own local revenues – mainly, revenues collected through taxes levied upon immovable property (real estate and land), means of transportation and several types of fees.

we took local taxes e-payments as a proxy for digitalization. Moreover, the control variables were chosen in order to isolate the tax collection variance not due to the digitalization effort.

We considered the geographical-political organization of Romania, four macro regions, as follows:

- Macro region 1 is composed of the following districts: Alba, Bihor, Bistrița-Năsăud, Brașov, Cluj, Covasna, Harghita, Maramureș, Mureș, Satu Mare, Sălaj and Sibiu.
- Macro region 2 has the following districts: Bacău, Botoșani, Brăila, Buzău, Constanța, Galați, Iași, Neamț, Suceava, Tulcea, Vaslui and Vrancea.
- Macro region 3 is composed of the following districts: Argeș, Prahova, Dâmbovița, Teleorman, Giurgiu, Ialomița, Călărași and București-Ilfov.
- Macro region 4 has the following districts: Dolj, Gorj, Mehedinți, Olt, Vâlcea, Timiș, Arad, Caraș-Severin and Hunedoara.

We used the annual data covering the period 2015–2021 in the case of macro regions 3 and 4, respectively, for the period 2016–2021 in the case of macro regions 1 and 2. From macro region 1, we removed Bistrița-Năsăud due to the lack of data for the before-mentioned period.

Table 2 illustrates the statistical indicators of the variables used in the panel regression models for all macro-regions. Regarding macro regions 1, 2, and 4, the standard deviation shows some variations in the GDP per capita because there are some differences in the districts of these macro regions. The standard deviation of GDP per capita from macro region 3 is much higher as the capital of Romania is part of this macro region and, in terms of economic development, is significantly more developed than other districts of Romania.

The minimum of GDP per capita is reached in Harghita district in 2016, while the maximum is reached in Cluj district in 2021 in the case of macro region 1. The less-developed district of Macro region 2 is Vaslui, with a GDPpc of 4000 EUR in 2016, while the maximum was reached in Constanța in 2021. As the capital of Romania is part of macro region 3, the maximum of GDPpc belongs to Bucharest in 2021, while the minimum belongs to Giurgiu in 2016. In the case of macro region 4, the maximum economic development was reached in Timiș in 2021, and the minimum was reached in Mehedinți.

The number of payments processed through ghiseul.ro increased during the analyzed period in all four macro regions, especially during 2020–2021. This could be considered a positive consequence of the pandemic. The minimum number of payments is registered in Maramureș in 2016, while the maximum is reached in Cluj in 2021 in the case of Macro region 1. As regards macro region 2, the maximum number of payments processed through the internet through ghiseul.ro belongs to Galați in 2021, while the minimum belongs to Neamț in 2016. The standard deviation of this indicator is relatively high in the case of macro region 3 as it includes the capital of Romania. The maximum of this indicator is reached in Bucharest 2021. Regarding macro region 4, the minimum number of payments processed through the internet through this platform belonged to Caras-Severin in 2015, while the maximum was registered in Dolj in 2021.

On average, the local tax revenues range between 111.5 million lei and 1.3 billion lei. As expected, the maximum belongs to macro region 3 as the capital is part of this macro region. At the opposite side of this interval, macro region 4 registers local tax revenues of

Table 2. Descriptive statistics of variables for Macro regions

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
Macro region 1					
Local_Tax	66	140 517 321.1	88 002 905.02	37 384 341	312 972 257.6
Pay	66	3798.8	4983.55	120	25 340
GDPpc	66	9870.3	2887.30	5800	17 457
Unemployment	66	3.1	1.17	1	5.8
Anet_E	66	2493.6	594.62	1519	4217
Macro region 2					
Local_Tax	72	123 359 986.1	74 059 783.38	50 484 367	349 116 379.3
Pay	72	5985.52	8602.34	115	46 278
GDPpc	72	7622	2488.69	4000	17 115
Unemployment	72	5.16	2.1	2	12
Anet_E	72	2375.68	506.01	1556	3728
Macro region 3					
Local_Tax	56	1 302 737 623	3 282 266 562	29 485 297	10 629 966 198
Pay	56	25 205,48	73 144.02	4	377 758
GDPpc	56	10 156	6949.28	3900	32 705
Unemployment	56	4.57	2.46	1.1	11.6
Anet_E	56	2479.5	731.32	1415	4833
Macro region 4					
Local_Tax	63	111 584 677	65 725 485.1	41 828 782	306 393 760
Pay	63	2961.19	5317.7	37	28 893
GDPpc	63	8898	2688.75	4500	16 998
Unemployment	63	4.15	2.38	0.6	9.8
Anet_E	63	2360.89	598.82	1431	4055

111.5 million lei. Macro regions 1 and 2 register average local tax revenues of 140.5 million lei and 123.5 million lei.

The standard deviation shows some minor variations in the unemployment rate. On average, the unemployment rate ranges between 3.1% and 5.6%, the highest average unemployment rate belonging to macro region 2 and the lowest to macro region 1. In the case of average net earnings, the standard deviation shows higher variations in the case of macro region 3. We expect this result, considering the capital of Romania is part of this macro region. The minimum of this macro region belongs to Teleorman in 2015, and the maximum belongs to Bucharest in 2021. In the case of macro region 1, the maximum of average net earnings was reached in Cluj in 2021, while the minimum in Harghita 2016. As regards macro region 2, the maximum of average net earnings belongs to Iași 2021 and the minimum to Vrancea 2016. Concerning macro region 4, the minimum was reached in Vâlcea in 2016 and the maximum in Timiș 2021.

1.2. Methodology (panel regression models)

We used several methodological approaches to achieve the research objective by combining the theoretical research through content analysis and the practical research through analytical processing by econometric methods. Thus, we have defined the macroeconomic indicators included in the database using the content analysis.

Next, we examined the effects of digitalization upon local tax revenues within the four macro regions of Romania. We ran a panel regression model for each macro region, using the EViews 12. We embark on the econometric analysis expecting that 3 out of 4 independent variables positively correlate with the dependent variable (mainly, the number of payments done through *ghiseul.ro* – as a proxy for digitalization; the gross domestic product per capita and the average net earnings). We expected the unemployment rate to have a negative impact on the local tax revenues. Regression analysis is used to test the relationship between two or more variables and determines the evolution of the dependent variable when one of the independent variables varies, thus allowing the identification of the variables with a more significant impact (Iuga & Mihalciuc, 2020). We opted for the panel data analysis and the generic empirical function is written as follows:

$$\text{Local\_Tax} = F\,(\text{Pay, GDPpc, Unemployment, Anet\_E}). \quad (1)$$

We performed a series of additional tests related to data stationarity and the correlation matrix for the chosen variables to determine the model specification. We ran a time series model, and all our variables were expected to be stationary (Feld et al., 2021; Koçak et al., 2021). Thus, we have chosen to use a "summary" option to get the results for several unit root tests (Levin, Lin & Chu; ADF – Fisher and PP – Fisher). After the unit root analysis, the correlation matrix for multicollinearity was run. The results of the tests are presented in the following section.

We applied the Estimated Generalized Least Squares (EGLS) method, using the Fixed Effects model for each macro region, as the result of Redundant Fixed Effects Test Likelihood Ratio indicated more consistent estimators with this model. We have chosen this method of analysis because this is the appropriate way to identify the estimated parameters in a linear regression when you have a certain degree of correlation (our main variables – LocalTax and Pay are intuitively correlated – the higher the number of payments, the higher the volume of collected revenues, also taking into consideration the increasing trend of local tax burden per measurement unit). By applying this method, we ensure that the GLS estimator is unbiased and consistent (Wooldridge, 2010). We also used Period SUR (Seemingly Unrelated Regressions) as a weighting method on the model equations. A SUR model is an application of the GLS approach, and the unknown residual covariance matrix is estimated from the data and has the advantage of being less cluttered (Wooldridge, 2010). Since then, the method has been applied in a series of studies with a variety of subjects (Adrangi & Kerr, 2022; Bojanic, 2020; Thiao, 2021). We applied logarithmic transformation for LocalTax, Pay, GDPpc, and Anet_E in order to have robust estimates coefficients (Fratila et al., 2021; Mudronja et al., 2020).

The equations can be written as:

$$\text{Macro region 1: } \ln\text{Local\_Tax}_t = a_1 \ln\text{Pay}_{t-1} + b_1 \ln\text{GDPpc}_t + b_2\, \text{Unemployment}_t + c_0 + u_t; \quad (2)$$

$$\text{Macro region 2: } \ln\text{Local\_Tax}_t = a_1 \ln\text{Pay}_{t-1} + b_1 \ln\text{GDPpc}_t + b_2 \text{Unemployment}_t + b_3 \ln\text{Anet\_E}_{t-1} + c_0 + u_{t.}; \quad (3)$$

$$\text{Macro region 3: } \ln\text{Local\_Tax}_t = a_1\, \ln\text{Pay}_{t-1} + b_1\, \ln\text{GDPpc}_t + b_2 \text{Unemployment}_t + c_0 + u_t; \quad (4)$$

$$\text{Macro region 4: } \ln\text{Local\_Tax}_t = a_1 \ln\text{Pay}_{t-1} + b_1\, \ln\text{GDPpc}_{t-1} + b_2 \text{Unemployment}_{t-1} + c_0 + u_t, \quad (5)$$

where, for Macro region 1 and Macro region 2: t = 2016…2021 and for Macro region 3 and Macro region 4: t = 2015…2021. a_1 – coefficient of lnPay; b_1, b_2 – coefficients of macro – regional level control variables; c_0 – constant; u_t – error term.

After estimating the models' results and verifying the maximum likelihood of the estimators, we used the following tests. Because the available data consists of a small sample – the study employs annual data from 2015 to 2021, in order to extract the inference, we employed the Fisher test (Agresti, 2007; McCrum-Gardner, 2008). Because the correlation matrix can be a good indicator of multicollinearity, we tested for multicollinearity through the correlation matrix of predictors. Cross-sectional correlation can be caused by unknown common shocks or spatial effects; thus, ignoring cross-sectional correlation in panel data analysis can lead to efficiency loss and invalid inference (Baltagi et al., 2016). Cross-sectional dependence is one of the most important diagnostics that should be investigated before performing a panel data analysis (Tugcu, 2018). In this context, the Breusch Pagan LM and the Pesaran CD tests have been conducted – the Pesaran CD test being an alternative to the Breusch Pagan LM. The null hypothesis states that there is no dependence between cross-sections, and this will be confirmed if the probability associated with the tests is higher than the threshold established. Normality is the most common assumption in applying statistical procedures in regression models because departures from normality may lead to substantially incorrect statements. Thus, a normality test is a "must" in any regression analysis (Thorsten & Herbert, 2007). We applied Jarque Berra test and the null hypothesis of the test is that the residuals are normally distributed at a p-value greater than the threshold of 5%.

In order to test for the autocorrelations of errors, the Durbin Watson test was used. The null hypothesis of the test assumes that the residuals are not autocorrelated, and for that to be accepted, the registered value of the statistic must be around 2. R-squared is a goodness-of-fit measure and shows the extent to which the independent variables explain the variation of the dependent variable in the model (Iuga & Mihalciuc, 2020). R-squared measures the strength of the relationship between the model and the dependent variable; thus, the higher the value, the better the independent variables have been chosen to explain the variation of the dependent variable. In any regression analysis, the coefficients and their associated p-values show which relationship in the model is statistically significant and the nature of that

relationship. By analyzing the significance of estimators, we try to identify the important variables for prediction and exclude others (Eliaz & Spiegler, 2022). The p-values test the null hypothesis – that the independent variable has no correlation with the dependent variable – and if the p-value is lower than the significance degree established, the null hypothesis is rejected. Alongside R-squared, the standard error of the regression is a goodness-to-fit for the regression analysis. All the tests' results are explained in the next section.

In order to test the robustness, we applied the methodology used by Jianu et al. (2021) and by Josifidis et al. (2017). According to the authors, the methodology implies excluding one year or one cross-section from the analysis in order to check how the results and signs of the coefficients (including standard errors) react, as EViews software does not provide a specific test for robustness.

2. Results

First, we tested the stationarity of data. Table 3 summarizes the outcome of the panel unit root tests. As can be observed, most of the variables are stationary in level, while some of them are in the first difference.

Table 3. Panel unit root tests output

Variable	Level – Macro region 1		
	LLC	ADF	PP
lnLocal_Tax	–10.1499***	25.3574	50.8785***
lnPay	–26.8914***	55.2150***	92.3430***
lnGDPpc	–36.6122***	58.0423***	94.3614***
Unemployment	–6.2931***	34.2885**	60.1104***
lnAnet_E	–7.05961***	22.5725	42.3747***
Variable	Level – Macro region 2		
	LLC	ADF	PP
lnLocal_Tax	–21.5499***	36.78886**	59.9815***
lnPay	–13.2548***	35.0226**	64.7339***
lnGDPpc^	–3.54435***	35.0715*	46.2121***
Unemployment	–7.28201***	77.2929**	102.511***
lnAnet_E	–11.7005***	45.3051***	106.369***
Variable	Level – Macro region 3		
	LLC	ADF	PP
lnLocal_Tax	–8.27624***	16.6009	30.8334***
lnPay	–5.50544***	25.9747**	55.7466***
lnGDPpc^	–9.11265***	39.2269***	54.9133***
Unemployment	–6.74847***	54.3027***	79.4075***
lnAnet_E	–3.70909***	10.1049	13.7500

End of Table 3

Variable	Level – Macro region 4		
	LLC	ADF	PP
lnLocal_Tax	–4.61592***	28.3031**	38.6524***
lnPay	–9.47897***	27.4703*	58.0932***
lnGDPpc^	–7.57703***	31.1899**	36.7538***
Unemployment	–3.81817***	33.2999***	61.8898***
lnAnet_E	–6.08234***	16.8641	27.6581*

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1, ^ first difference; lag lengths are determined by using the Schwarz Info Criterion.

Then we examined the correlation between the variables using the correlation matrix to solve the problem of multicollinearity. A positive or a negative correlation greater than 0.8 serves as a threshold for a correlation presence (Lovrić, 2005; Wirtz & Daiser, 2018). The review of the correlation coefficients shows that there are strong linear associations between average net earnings and the payments processed through ghiseul.ro (used as a proxy for digitalization) in the case of Macro regions 1, 3, and 4. As a consequence, we solved the problem of multicollinearity by removing average net earnings from the macro regions mentioned above.

Table 4 shows the correlation coefficients of the variables.

Table 4. Correlation matrix

Macro region 1	lnPay	lnGDPpc	Unemployment	lnAnet_E
lnPay	1			
lnGDPpc	0.6817	1		
Unemployment	–0.4466	–0.5649	1	
lnAnet_E	–0.8725	0.8362	–0.5138	1
Macro region 2	lnPay	lnGDPpc	Unemployment	lnAnet_E
lnPay	1			
lnGDPpc	0.3898	1		
Unemployment	–0.2204	–0.5507	1	
lnAnet_E	0.6942	–0.6328	–0.3329	1
Macro region 3	lnPay	lnGDPpc	Unemployment	lnAnet_E
lnPay	1			
lnGDPpc	–0.0772	1		
Unemployment	0.2843	–0.0515	1	
lnAnet_E	0.8797	0.0419	0.3786	1
Macro region 4	lnPay	lnGDPpc	Unemployment	lnAnet_E
lnPay	1			
lnGDPpc	0.5700	1		
Unemployment	–0.0137	–0.5774	1	
lnAnet_E	0.8113	0.7518	–0.3244	1

The effects of digitalization (proxy by payments processed through *ghiseul.ro*) upon local tax revenues within the four macro regions of Romania are presented in Table 5. The empirical results are in line with our expectations, Macro region 3 being the exception.

Table 5. Results of the panel regression models

	Macro Region 1	Macro Region 2	Macro Region 3	Macro Region 4
	lnLocal_Tax	lnLocal_Tax	lnLocal_Tax	lnLocal_Tax
lnPay	0.1345*** (0.0388)	0.0943*** (0.0340)	0.6587*** (0.0823)	0.3232*** (0.0266)
lnGDPpc	0.6543*** (0.2311)	0.9623*** (0.2625)	–1.6115** (0.7385)	0.3989*** (0.1405)
Unemployment	–0.3485*** (0.0470)	–0.0308*** (0.0130)	0.1168*** (0.0384)	–0.0279*** (0.0064)
lnAnet_E		2.0221** (0.7711)		
Constant	12.5946*** (2.1256)	–6.3152 (5.8967)	14.1143*** (0.6301)	8.8341*** (0.5458)
R^2	0.8703	0.6663	0.7769	0.8741
Durbin-Watson	1.5178	1.7746	1.6108	1.8827
Jarque-Bera (p-value)	0.1427	0.0512	0.3548	0.7820
Breusch Pagan LM (p-value)	0.4117	0.2242	0.6277	0.8258
Pesaran scaled LM (p-value)	0.8718	0.4657	0.6888	0.3482
Observations	55	60	48	54
Number of districts	11	12	8	9

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Standard errors in parentheses.

Our results show that, indeed, digitalization has an impact upon local tax revenues, but it differs across macro regions. The highest impact of payments processed through the internet upon local tax revenues was obtained for Macro region 3, with an estimated coefficient of 0.6587. The coefficient is statistically significant and indicates that if payments processed through ghiseul.ro increase by 10%, the local tax revenues increase by 6.587% on average. We expected this result, as Macro region 3 contains the capital of Romania (Bucharest), which is highly digitalized. The lowest impact of digitalization upon local tax revenues was obtained for the Macro region 2, with an estimated coefficient of 0.0943, indicating that if payments processed through ghiseul.ro increase by 10%, the local tax revenues increase by 0.943% on average. This macro region could be considered less developed as the average GDPpc is 7622 euro compared to 10156 euro from macro region 3.

Regarding Macro region 4 and 1, we obtained an estimated coefficient of 0.3232 and 0.1345. The coefficients are statistically significant and indicate that if payments are processed through ghiseul.ro increase by 10%, the local tax revenues increase by 3.232% on average in the case of Macro region 4 and by 1.345% in the case of Macro region 1. Thus, our findings are similar to Bulai et al. (2019).

Different results for different regions were observed by previous researchers. For instance, Attour and Chaupain-Guillot (2020) found that different contextual factors may justify differences in quantity (the number of e-services) or the quality of the e-services offered by the local government. Gombár et al. (2022) found significant differences in the perception of Slovak taxpayers of the tax compliance costs, depending on the region they lived in.

The model's control variables are statistically significant and have the expected positive or negative impact on local tax revenues, except in Macro region 3 where they have opposite signs. This exception could be interpreted in the following way: as the standards of living increase, the share of local taxes in the net income will decrease, and thus, the impact of GDPpc could become lower or negative. The same result was obtained by Hanrahan (2021). Spatari (2020) also sustains the idea of a regressive property tax system in Romania. In the case of unemployment, the positive relationship could be explained by the fact that most likely individuals from Macro region 3 who pay local taxes are usually employed (or otherwise, the unemployed individuals from Macro region 3 do not own properties, such as land, apartments, houses, or cars).

In the case of Macro regions 1, 2, and 4, the standards of living stimulate the local tax revenues. Consequently, we obtained an estimated coefficient of 0.6543 for Macro region 1, 0.9623 for Macro region 2 and 0.3989 for Macro region 4. The results indicate that if GDPpc increases by 10%, the local tax revenues increase by 6.543% on average in the case of Macro region 1, by 9.623% on average in the case of Macro region 2 and by 3.989% on average in the case of Macro region 4. Regarding unemployment, we obtained an estimated coefficient of –0.3485 in the case of Macro region 1, indicating that an increase of 10 percentage points of unemployment will decrease 3.485% on average for local tax revenues. In the case of Macro region 2 and 4, the estimated coefficient is –0.0308 and –0.0279, indicating that if unemployment increases by ten percentage points, the local tax revenues will decrease by 0.308% and 0.279% on average. A positive relationship can be seen between average net earnings and local tax revenues in the case of Macro region 2.

The results of tests for the absence of residuals' autocorrelation, normal residuals' distribution, and absence of dependence between cross-sections are presented in Table 5. According to Durbin Watson test, the results indicate that errors are not autocorrelated from all Macro regions. Additionally, according to Jarque–Bera test, the residuals are normally distributed. A p-value greater than 0.05 confirms the test's null hypothesis, which claims that the residuals are normally distributed. Finally, a p-value greater than 0.05 confirms the null hypothesis of Breusch Pagan LM and Pesaran scaled LM indicating that there is no dependence between cross-sections in none of the Macro regions.

Regarding the robustness testing, we obtained that there are no significant large-scale differences between the results obtained in the baseline model and the models we have run by excluding one year or one cross-section in the four macro-regions. This confirms the robustness of the results.

Previous research (Bassey et al., 2022; Diga & May, 2016; Pippin & Tosun, 2014) underlines that the technology itself is not the problem. Rather it is the complex social context in which the technology operates: urban/rural environment, education level, social classes, computer literacy. Therefore, these elements may be the cause of differences between

tax collection in developed macro-regions (Macro region 3) and developing macro region (Macro region 1). Additionally, some academic work noticed the improved quality of life when e-services are in place (Maiga & Asianzu, 2013) because bureaucracy is reduced and transparency is increased (Floropoulos et al., 2010). As we demonstrated in the results section, the collection tax rate has improved, therefore, we may state that the e-services platform (ghiseul.ro) acts as a tool for better government performance (Decman et al., 2010; Mpofu, 2022). Thus, our empirical results suggest that, in the post-Covid era, the use of information technology is essential for the government in its journey to revitalize and modernize the relationship with taxpayers. Although it was expected for the digitalization to stimulate the revenue collected, our study shows for the first time the correlation between the availability of e-payments solutions, tax revenue and other variables, such as the GDP and unemployment. It is of use for public authorities to help them direct their efforts in their work to increase the tax collection.

Furthermore, from a practical standpoint, the outcomes of this study highlight that electronic platform used to collect local taxes may improve tax compliance, monitoring real-time revenue collection, performing audits, and using big data to assess taxpayer risks, but a colossal challenge is reorganizing and restructuring the institutional arrangements in which e-transactions are embedded. A study published by World Bank (2016) assesses that electronic filing and payments have on average reduced the time for taxpayers and tax authorities by 25 percent in the five years after the digital system was introduced. The policy makers and e-government managers may take advantage of our results which may be a helpful reference in designing digital tax services and to strengthen inter-regional collaboration.

Conclusions

In Romania, the digitalization of tax collection is at the beginning, and the benefits are distinguishable, but not yet quantified. Digitalization of Romanian public administration is based on the strategy developed in line with the European Digital Agenda as the framework of reference to determine how to boost the digital economy for 2014–2020. Part of this strategy is to offer more e-services to citizens and to move from the cash payments towards e-payments.

Despite the current focus on the tax challenges of digitalization by policymakers and academia, digitalization and its impact on taxation is here for the long run. Our research broadens the literature on the impact of digitalization of the public administration, by attempting to quantify the influence of digitalizing the public services, especially the payments, on the tax collection, considering the economic idiosyncrasy of geographical-political areas from Romania.

As such, the current empirical analysis exploits the data available on the platform *ghiseul.ro* and analyzes how the e-payment of local taxes varied over the period of 2015–2021 by grouping the data into panels corresponding to four macro regions according to their geographical-political characteristics. Our results are mostly in line with expectations: the digitalization, expressed as the number of payments through the electronic platform *ghiseul.ro* (lnPay), leads to an increase in tax collection ($p < 0.001$) for all four macro regions. As a measure of economic development of the region, the coefficient for GDP per capita is

negative only for Macro region 3 and significant at the 5 percent level. The results illustrate that developed regions, with higher GDPpc and lower unemployment rates, record a higher degree of tax collection through electronic platforms compared to less developed regions.

There are a few limitations regarding the current study. Firstly, the data extracted from the platform ghiseul.ro do not cover all the cities in the macro-regions observed, but only the main ones. We believe that this is not a severe limitation as it is unlikely for the rest of the cities to present different trends than the one shown already. Secondly, in terms of methodology, we had a limited number of options because the number of years is smaller than the number of districts within the macro-regions. Thirdly, the data used in our research only comes from the Romanian centralized e-payment platform. As said, some cities may have their local e-payment platforms. We also do not believe that this is a significant drawback as the e-payment platform we used is, by far, the most well-known one, according to the public authority in charge of managing it.

Future directions of this study could consist in the analysis of some demographic determinants of users of platform *ghiseul.r*o (for instance, education level, age or social class) and user experience analysis after using the platform.

Overall, digital technology offers opportunities to increase access to information, reduce transfer costs, and automate certain activities. Therefore, further research may address the impact of digitalization on tax collection in different countries (emerging and/or developed), covering longer periods before and after the Covid-19 pandemic. That would be particularly important as a first step to identify sustainable ways to digital transformation of the public administrations in the absence of outbreaks.

Author contributions

Conceptualization, A.F., M.P., M.N, and P.L.; methodology, A.F., P.L.; software, A.F.; validation, A.F.; formal analysis, A.F.; investigation, A.F.; resources, A.F., M.P., P.L.; data curation, A.F., P.L.; writing–original draft preparation, A.F., M.P., M.N, and P.L; writing–review and editing, A.F., M.P., M.N, and P.L; visualization, A.F., M.P., M.N, and P.L; supervision, A.F., M.P., M.N, and P.L.; project administration, A.F., M.P., M.N, and P.L.; funding acquisition, A.F., M.P., M.N, and P.L. All authors have read and agreed to the published version of the manuscript.

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