Economics
The Open-Access, Open-Assessment E-Journal

Discussion Paper
No. 2018-79 | November 08, 2018 | http://www.economics-ejournal.org/economics/discussionpapers/2018-79

Regional tax effort in Spain

Anabel Zárate-Marco and Jaime Vallés-Giménez

Abstract
This work examines in depth the hypotheses explaining the tax capacity of regional governments, also determining their tax effort and explanatory factors. The study is done for the Spanish regions, using different techniques which have rarely been applied in this area. The results show that these jurisdictions have exercised their tax autonomy responsibly, in response to different political, budget, and demographic factors and to the economic cycle. Also, an asymmetrical tax behaviour linked to income is observed: some regions have practically exhausted the possibilities of current sub-central taxes, while others still have ample fiscal space.

JEL H71 H2 C23 C51
Keywords Regional tax effort; regional taxes; tax potential; frontier techniques

Authors
Anabel Zárate-Marco, University of Zaragoza, Spain, azarate@unizar.es
Jaime Vallés-Giménez, University of Zaragoza, Spain

The authors gratefully acknowledge the funding support of the Spanish Institute for Fiscal Studies, the Regional Government of Aragón and the European Regional Development Fund (Public Economics Research Group). The usual disclaimer applies.

Citation Anabel Zárate-Marco and Jaime Vallés-Giménez (2018). Regional tax effort in Spain. Economics Discussion Papers, No 2018-79, Kiel Institute for the World Economy. http://www.economics-ejournal.org/economics/discussionpapers/2018-79

Received October 23, 2018 **Accepted as Economics Discussion Paper** November 1, 2018
Published November 8, 2018

1. Introduction

Empirical literature has been little interested in knowing the tax effort of sub-national governments, although it would allow to test the accuracy both of the complaints of insufficient funding by some sub-central jurisdictions which portray themselves as victims, and of the central government's accusations of a lack of sub-central fiscal responsibility. This is particularly desirable in the current context, when the different levels of government are blaming each other for the effects of the economic recession and budget imbalances.

For this reason, the goal of this work is to quantify the use regional governments make of their potential tax capacity, and examine the causes explaining their tax effort, based on an empirical exercise for the Spanish regions during the period 2002-2012. The work presents several methodological peculiarities differentiating it from the emerging international literature on tax effort at the sub-central level. First, we use several frontier methods, some of which have rarely been applied in this field. Second, we extend the explanatory hypotheses of potential tax revenue, by combining general indicators with other specific indicators of tax capacity. And finally, we use a dynamic approach with panel data considering total tax revenue, rather than the cross-section estimates more often found in this type of study, or the partial works which consider only one tax.

The work is structured as follows. In the next section, we define the concept of tax effort, and review the available literature on the subject and the different methodologies applied in its study. In the third section, we briefly explain the Spanish regional funding system which is the subject of our study. In the fourth section, we propose explanatory hypotheses for the tax potential and tax effort of those regions. The fifth section presents the estimates and calculations of tax effort. The results show that the Spanish regions have exerted a strong tax effort, and that in general, they do not have much room to manoeuvre to raise tax revenues, although we find significant asymmetry placing some regions at the limits of their potential tax income, while others still have considerable fiscal space. The work concludes with a section of final thoughts.

2. Review of the literature on tax effort

The concept of tax effort is subjective and hard to evaluate, as it is not directly observable. This is attested by the fact that several approaches to it have been suggested in the literature, but none has been universally accepted as satisfactory. The most widely recognised tendency in the literature considers tax effort to be the degree to which a jurisdiction effectively uses its tax capacity. The tax capacity of a jurisdiction can be defined as the volume of tax resources which a government can obtain when making full use of its regulatory power over the taxes within its reach, with effective management of them (legal tax capacity). However, an economic approach is normally used, which determines the maximum tax revenue a jurisdiction can obtain given its economic, social, institutional, and demographic characteristics (economic tax capacity). In this way, the numerator of the tax effort (the exercised tax capacity or real revenue collected) depends on the action of the government, as higher tax rates, or more intense efforts in tax management and inspection leading to lower tax evasion, raise the effective tax collected. Meanwhile, the denominator (tax capacity) is independent of the action of the government (Jorge Martínez-Vázquez and Jameson Boex, 1997), and as this variable is unobservable, this figure is difficult to quantify.

In practice, various ways have been put forward of measuring this tax capacity. This has sometimes been done through macroeconomic indicators such as the income or wealth of the territory which is a straightforward and inexpensive option. Unfortunately, this method may not reflect the true capacity of sub-central governments to obtain resources through their own taxes, and may not capture the uneven distribution of specific tax bases, such as those linked to mineral resources, for example. A pioneering example of this school of thought is Henry Frank's (1959) index, which defines tax effort as the quotient between the fiscal pressure of the jurisdiction and its per capita income. The drawback of this index is that it shows excessively high values in low-income territories, even if their citizens pay low taxes. The Relative Tax Effort Indexes of Guillem López-Casasnovas and Albert Castellanos (2002) are more advanced and interesting, territorialising taxes through variables intended to approximate the tax revenue capacity of each region.

An alternative method to approximating tax capacity is the Representative Revenue System (Advisory Commission on Intergovernmental Relations- ACIR, 1988). This method calculates the potential revenue governments would obtain from their own taxes if they applied a standard tax rate (López-Casanovas and Castellanos, 2002; Julio López-Laborda, 2015) to the different tax bases available to them, managing the taxes with a standard efficiency level. This line would be followed by the proposal of Ángel De la Fuente (2013), who applies the average tax rate imposed by the set of regions. Although the Representative Revenue System has significant theoretical advantages, it has the disadvantage that the regional tax bases are not always available, making it necessary in many cases to resort to proxies of those tax bases, with varying success, depending on the information available in each case. This in turn means making subjective decisions in the process of evaluating the different types of taxes. Another disadvantage is that if the decentralised tax bases are not closely linked to regional income, resources may be transferred from low-income regions to rich ones through equalisation grants. And depending on the standard tax rate used, it can lead to a certain instability in the revenues of sub-central governments by incentivising strategic behaviour, such as setting sub-optimal tax rates (Ana Herrero and Jorge Martínez-Vázquez, 2007; López Laborda, 2015).

The econometric method has been the most popular for empirical studies of tax capacity. This is an indirect method used to estimate tax capacity based on regressions of observed tax revenue according to objective, non-manipulable indicators, used as proxies for the tax bases. The first econometric applications used the least squares analysis (OLS) to estimate the average tax capacity of a jurisdiction, given its tax bases, economic structure, institutional aspects, and demographic trends. Based on that estimate, tax effort is obtained by comparing real tax revenue with the average estimated using the regression. With the OLS estimate, the error term can be positive or negative, i.e., the calculated tax efforts can be over 100%, so that a jurisdiction may deviate above or below the predicted average. There are many works using this methodology to study tax effort at the national level (from the pioneering Jørgen Lotz and Elliott Morss, 1967, to the recent work of Tuan Mihn Le, Blanca Moreno-Dodson and Nihal Bayraktar, 2012); however, there are hardly any studies at the sub-central level (Herrero and

Martínez-Vázquez, 2007, and José M. Cordero, Roberto Fernández, Carolina Navarro, Francisco Pedraja, Javier Suárez and Alfonso Utrilla, 2010).

More recently, a novel methodology based on the stochastic frontier of production possibilities, proposed by Dennis Aigner, Knox Lovell and Peter Schmidt (1977), has begun to come into use. This methodology applies maximum likelihood techniques to estimate a stochastic tax frontier, as it is understood to provide a better fit for the potential tax capacity of a jurisdiction than the average behaviour provided by the OLS approach. In this way, the tax capacity of a jurisdiction will be considered as the maximum revenue level it could obtain with a virtuous use of its tax bases and efficient management of its taxes, taking as a benchmark the best results reached by the set of jurisdictions with similar conditions over the whole period considered. The SFA is based on the idea that no economic agent can be located beyond the frontier, so that the tax effort obtained by comparing real tax revenue with the frontier or the potential revenue estimated with stochastic frontier analysis cannot exceed 100%. Thus, any deviation from the frontier represents each jurisdiction's margin for manoeuvre to raise its revenue to the "potential" maximum. This methodology has been used in a few studies of tax effort at the central level, such as Carola Pessino and Ricardo Fenochietto (2010), and Musharraf Cyan, Jorge Martínez-Vázquez and Violeta Vulovic (2014); and in the regional-level work of Raghbendra Jha, M. S. Mohanty, Somnath Chatterjee and Puneet Chitkara (1999), Roberto Ramírez and Alfredo Erquizio (2011), Sandhya Garg, Ashima Goyal and Rupayan Pal (2017), and even the preliminary approximation of Augusto F. Medina (2012) for the Spanish regions. Also relating closely to our research is the literature using stochastic frontier techniques to analyse the tax collecting efficiency of public administrations (James Alm and Denvil Duncan, 2014).

Although to a much more limited extent, other techniques can be found in tax effort studies, which although not parametric, share the frontier approach discussed above, and are frequently found in evaluations of the efficiency of units of production. Data envelopment analysis (DEA) has been used to measure the tax effort of municipalities in Colombia (Departamento Nacional de Planeación, 2005) and in several states in India (Colin Thirtle, Bhavani Shankar, Puneet Chitkara, Somnath Chatterjee, Madhu

S. Mohanty, 2000, and Indira Rajaraman and Rajan Goyal, 2012). Data envelopment analysis (DEA) is a linear programming technique which facilitates the construction of an enveloping surface for calculating a synthetic indicator of relative efficiency. Regions obtaining the maximum level of tax revenue from the tax bases they use would be on the frontier, so that the tax collecting margin of other regions could be measured by their distance from the frontier. Given that this is a non-parametric method, there is no need to know the functional form of the input-output relationship; neither is it a statistical method, so there is no need to set a probabilistic distribution of inefficiency.

Its non-convex version, the Free Disposal Hull (FDH) model, has been less used - as far as we know, only Enlinson Mattos, Fabiana Rocha and Paulo Arvate (2011) have used it to measure efficiency in the collection of municipal taxes in Brazil. FDH is a special case of DEA, with the distinguishing feature of not requiring convexity, and that the benchmark units for comparison of the collections are real decision units, giving meaning to the comparison between decision units. With FDH, a jurisdiction which does not exploit its maximum tax-gathering potential will be compared with a real jurisdiction which obtains more tax income in similar socioeconomic conditions, rather than a virtual one constructed from linear combinations (as in the DEA model).

Recently, extensions to this methodology have appeared, known as Order-m (Catherine Cazals, Jean-Pierre Florens and Léopold Simar, 2002) and Order-α (Y. Aragon, Abdelaati Daouia and Christine Thomas-Agnan, 2005) partial frontier approaches. These approaches do not envelop all the data, and although they are beginning to be used in business efficiency studies, they have yet to make an impact in the field of fiscal federalism, except for the contribution of Jaime Vallés-Giménez and Anabel Zárate-Marco (2017). These non-parametric partial frontier methods are interesting because they permit atypical efficient or super-efficient observations - i.e., beyond the estimated tax revenue frontier, making it possible to greatly reduce sensitivity to errors of measurement and outliers. Thus, this method can reduce the possible impact on tax revenue comparisons of, for example, regions with significant unusual taxation features or with natural resources which facilitate high tax revenues.

To sum up, a comparative review of the literature enables us to conclude that there is ample international empirical evidence for calculating tax effort at the national level, although there are still few empirical studies of sub-central governments. The problem of the availability of applied research is exacerbated by the lack of necessary information in many countries, especially for works that consider several years at the same time (panel data). Meanwhile, the literature offers a wide range of techniques for calculating tax effort, allowing us to take advantage of the merits of each one and check the robustness of the results obtained, while being aware of the limitations of each approach.

3. The Spanish regional funding system

Our study will consider the set of Spanish regions in the common funding system (therefore excluding the Basque Country and Navarre, the two regions with their own special funding system), as it presents a series of characteristics making it ideal for analysing these aspects. On one hand, in the Spanish regional funding system, jurisdictions have a high degree of tax autonomy, which allows for a large enough fiscal space for heterogeneous tax behaviour to appear within a common national framework. On the other, the equalisation transfers model for Spanish regions considers their tax effort as one of the factors determining the allocation of grants, though the tax effort indicator used is not calculated appropriately. Also, the aggregate budgetary balance at the regional level masks the coexistence of heavily indebted regions (e.g., Catalonia and Valencia) alongside financially sound ones (e.g., Galicia and the Canary Islands). This heterogeneity is extremely interesting, because by studying how the different Spanish regions have used their tax authority, we can assess whether they are justified in borrowing to mitigate the shortfalls of the regional funding system, or whether the central government should intervene to correct the low sub-central tax effort.

Comparatively, the Spanish regions are among the sub-central jurisdictions with the most autonomy to manage their spending and revenue, although historically they have had a smaller margin of discretion. They can support their spending policies with transfers from higher levels of government through various funds, borrowing (with strict limits), and a plethora of their own and assigned taxes.

The regions have gradually introduced their own taxes, where they are responsible for every aspect of performance, application, and regulation. These are usually environmental taxes with low potential revenue, given the restrictions of the Regional Funding Act (LOFCA) for establishing taxes on matters already taxed by other levels of government. For a detailed list of the tax measures adopted by each region, see the annual reports published by the Ministry of Finance and Civil Service (Ministerio de Hacienda y Función Pública- MHFP).

In contrast, the taxes whose collection is, totally or partly, assigned by the State to the regions (hereafter, assigned taxes), provide 90% of the non-financial revenues of the regions, and as shown in Table 1, they have a certain degree of regulatory or decision-making power over many of those assigned taxes, which they can exercise within limits. The regions have more regulatory power over Inheritance Tax (ISD), Estate and Property Transfer Tax (ITPAJD), Wealth Tax (IP), Gambling Taxes (TJ), and Personal Income Tax (IRPF), only 50% of which is assigned, than over the Special tax on fuels (IH) and the Tax on Certain Forms of Transport (IDMT), where the regions have some power over the tax rate. Meanwhile, they have no regulatory power over Value Added Tax (VAT), Special Taxes on the manufacture of alcoholic drinks and tobacco, or the Special tax on electricity (IE). In these taxes the regions only have territorialised shares of 50%, 58%, and 100% of revenue, respectively. The regions can also set surcharges on certain State taxes. And additionally, as shown in the last column of Table 1, they have powers relating to management of the IP, ISD, ITPAJD, TJ, IDMT, and the Tax on Retail Sales of Certain Hydrocarbons, included in the IH since 2013.

Thus, the volume of tax revenue in the Spanish regions may be influenced by at least five factors. First, regional governments have discretion to set tax rates for the majority of assigned taxes. Second, in many cases they also have regulatory power to establish other tax elements, such as exemptions, rebates, and tax deductions. Third, the regions manage, monitor and inspect taxation, tasks which may affect the total tax base and thus, tax revenue. Fourth, they can use techniques which combine the previous three mechanisms, so that if the amount of the tax base is increased they can reduce the tax rate applied, or establish more deductions or rebates, for example. And finally, they can establish their own taxes, and surcharges on certain other taxes. All of this means that the regions have the power to make decisions on approximately one third of total regional tax revenue, and that there are sufficient optional elements to give them a significant capacity to affect regional taxes. For this reason we feel it is important to quantify the available or unexploited tax margin within the reach of this level of government.

(Insert table 1 here)

4. Factors explaining the stochastic tax frontier and tax effort of the Spanish regions

Our study is based on the implementation of the Stochastic Frontier Approach (SFA). The SFA is a parametric technique which is increasingly popular around the world in empirical studies of tax effort. It lets us identify the factors explaining the different levels of tax effort, estimating them simultaneously with potential or frontier tax revenues and their determining factors.

Statistically, it means specifying a regression model for the tax frontier, with two error terms. With an output approach, this could be represented as follows:

$$ln\ TAX_{it} = \beta_0 + \Sigma^{m}_{k=1}\beta_k\ lnx_{kit} + v_{it} - u_{it} \qquad [1]$$

where TAX_{it} will be the tax revenue for the region i in the year t, with i = 1, 2, …, 15 and t = 2002, ..., 2012; x_{kit} represents a vector of values corresponding to k relevant variables to explain the tax capacity of region i in the year t; β_k corresponds to a vector of parameters to be estimated; and β_0 is the common constant for all the regions in the year t. The error term, v_{it}, represents the usual statistical noise, i.e., everything beyond the control of the region, and is assumed to be independent and identically distributed as a $N(0, \sigma_v^2)$. The second error term, u_{it}, represents the error in obtaining the maximum amount of revenue for given inputs or tax bases, and would be the function of variables z_{it}, which may vary over time and would include observed heterogeneity.

$$u_{it} = \delta z_{it} + w_{it}, \qquad [2]$$

where δ is a coefficient vector to be estimated and w_{it} is the error term.

Endogenous variable

We took as endogenous variable (output) the regional tax revenue, TAX, considering all tax sources (own and assigned taxes, with and without regulatory power) which may be distributed in very unevenly among the regions due to uncontrollable external factors, as this is the only way to avoid the risks arising from the possible substitutability and interdependence of the different forms of obtaining tax revenues by this level of government (ACIR, 1988).

Factors determining tax potential

To choose the inputs or explanatory variables of the tax potential, we considered the available empirical evidence on sub-central tax behaviour, and performed a series of estimates to select the best indicators of regional tax potential, bearing in mind their explanatory capacity. We also took into account that tax capacity is independent of government decisions or actions, which excludes the consideration of variables such as tax rate. Specifically, we estimated the real revenue collected for each assigned tax and for the total aggregate, according to the main macroeconomic regional indicators which can explain that revenue, and alternatively, a series of proxies of their respective tax bases (as the territorialised tax base information needed to estimate revenue from the taxes considered does not exist). Given that assigned taxes represent approximately 90% of the non-financial revenues of the regions, the explanatory variables of the assigned taxes will also provide a good explanation of the endogenous TAX or total tax revenue. Table A.1 of the Appendix shows the definition of each variable used, the source the data were obtained from, and the main descriptive statistics of the variables. The matrix of correlations is presented in Table A.2. All the nominal variables were deflated according to the corresponding regional price index.

These estimates can be seen in Table A.3 in the Appendix. The upper part of the table shows the estimated revenue (for each assigned tax and for the aggregate) according to the specific tax bases, and the lower part shows the results for the general indicators of tax capacity (income and population). The estimation used the robust errors method proposed by John C. Driscoll and Aart C. Kraay (1998) and adapted by Daniel Hoechle (2007). This methodology generates robust estimates of tax capacity and can be used when the residuals are nonspherical, and without the need for the sample to be homoscedastic or for absence of serial and contemporary correlation (XTSCC estimates). In our case, this is recommended by the Wooldridge, Wald, and Pesarán tests, respectively. Other methods which let us simultaneously eliminate the problems mentioned are Parks-Kmenta feasible generalized least squares (FGLS), and Beck and Katz´s panel corrected standard errors (PCSE), although the former cannot be used when T<N, as in our case, and the latter perform better with smaller samples.

The results of these estimates demonstrate that the two general indicators of tax capacity often used in the literature, population (POP) and income (INCOME), provide a fairly satisfactory explanation of revenue for most individually considered taxes and for the aggregate; although it seems to be necessary to include a specific proxy for the tax bases linked to wealth and gambling in order to mitigate the defects shown by general indicators in the individual estimation of these taxes (IP and TJ, respectively). Thus, as seen in Table 2, to estimate the tax potential or equation [1] of the stochastic frontier model, we used as explanatory variables or inputs the two general indicators of tax capacity (POP and INCOME), the proxies of the wealth tax base (stock of private capital, STOCKP) and the gambling tax base (regional expenditure on gambling, GAMBLINGEXP), and different features of the institutional context arising from the heterogeneity of the sample, which this technique lets us capture with dummy variables on the frontier. With the dummy variable DPROV, we identify the single-province regions, which enjoy both regional and provincial revenues, as they assume the responsibilities of the Provincial Governments; with the qualitative variable CAN, we identify the region of the Canary Islands, given the unique features of its tax system, associated with its characteristics as an ultra-peripheral region of the European Union (article 349 of the Treaty on the Functioning of the European Union); and with the trend variable, TEND, we capture the impact of the passage of time on tax revenue and the learning effect in the regions, which have seen their tax autonomy increase significantly from 2002 (the first year of our sample) when more taxes were assigned in line with Law 21/2001. We also include a qualitative variable (IP09-11) which captures the years 2009-11, when in practical terms no Wealth Tax (IP) was collected. We tried including other variables (the unemployment rate, the weight of the agricultural sector, etc.) but they were not significant or did not improve the model. We also tested the regional tax fraud levels, based on the estimates of the Finance Ministry Union (GESTHA), but this variable was not significant either, probably due to the lack of an official estimate of suitable quality.

Explanatory hypotheses of tax effort

In taxation, the difference between real output and the output determined by the tax frontier can only be interpreted as the unobtained part of the potential tax revenue, but it cannot be considered a measure exclusively associated with inefficiency. Therefore, we have proposed that heterogeneous behaviour in the use of potential tax revenues, or equation [2], could be caused by several factors.

Political variables: We think that each regional government may deliberately make a high or low tax effort. To take this into account, on one hand, we have included two qualitative variables: dPOLITCOLOUR, intended to show whether tax effort depends on the ideology of the party in power in the regional government, and dSINT, which identifies when the regional and federal governments are ruled by the same party and thus in harmony with each other. On the other hand, we have included two variables intended to capture the political will of a set of regions which have been strongly committed to exercising their tax autonomy (although we must take into account that the regions are left with hardly any taxable areas where they can apply their own taxes). The variable ACTIVISM1, identifying the tax effort of regions which the Order-α technique puts outside the partial revenue frontier due to more active behaviour in terms of tax effort (this can be seen in Table 3 of the section on results). As we have explained, partial frontier methods let us identify regions whose tax behaviour is atypical or super-efficient - in other words, located beyond the estimated potential tax revenue frontier, due to their specific fiscal characteristics: either because the territorial distribution of some tax bases is extremely uneven, or because there happens to be an especially intense taxable activity there (e.g., property sales in coastal tourist areas), among other possible causes. And the variable ACTIVISM2, which captures the volume of revenue from the region's own environmental taxes, which is an unmistakable sign of the will to exercise the tax autonomy the law confers on the regions to obtain tax revenue.

Budget variables: The region's tax behaviour may also be determined by its budget situation, and so our model takes into account the existence of income sources other than taxes, and the spending needs of the regions. On the income side, we included the variable TRANSFREV, which measures the volume of transfers from higher levels of government and which may generate fiscal illusion and thus lead to low tax effort; and the variable PATREV, which shows income from the management of regional assets, specifically, revenue from assets and the disposal of real investments, which may complement or replace tax income. As indicators of the will to exercise self-government and the need for income, we have included the volume of non-financial current expenditure (NFEXP) and financial expenditure (FEXP), which will enable us check whether the regional funding model has allowed a certain margin of financial autonomy, requiring greater tax effort from jurisdictions with higher spending.

Demographic variables: We have also considered demographics with the variables of density (DENSITY) and changes in population (POPGROWTH). A positive sign for DENSITY might be capturing scale economies in tax management, and a positive sign for POPGROWTH could show the difficulty of administrating and managing growing populations which are not considered in the funding system: the system sets the population at the level of the base year considered, obliging jurisdictions with faster demographic growth to make a greater tax effort.

Inefficiency: Regional differences in tax behaviour may arise from inefficiency in the tax collection and management process, which could be due to poor management, the use of obsolete technology, a lack of suitable human resources, corruption, tax evasion, etc. To capture this inefficiency, we have included the variable QMANAG, which shows the relationship between the non-financial current income the region really receives and the income it budgets for.

Economic cycle: Finally, we have included the variable CRISIS to reflect the impact of the economic and property recession on regional finances and tax effort.

5. Results of the estimation for the tax frontier and regional tax effort

In light of the hypotheses described above, we used panel data (2002-2012) to estimate equations [3] and [4] of the stochastic frontier model proposed by William Greene (2005). This is a time-varying model, the True Random Effect (TRE) model (although the fixed effects approach gives similar results), estimated by applying the maximum likelihood procedure, with the following econometric specification:

$$TAX_{it} = \alpha_i + f(INCOME, POP, STOCKP, GAMBLINGEXP, CAN, DPROV, IP09\text{-}11, TEND) + v_{it} - u_{it} \quad [3]$$

$$u_{it} = g\,(dPOLITCOLOUR, dSINT, ACTIVISM1, ACTIVISM2, TRANSFREV, PATREV, NFEXP, FEXP, DENSITY, POPGROWTH, QMANAG, CRISIS) + w_{it} \quad [4]$$

This specification considers that inefficiency may vary over time, and the inefficiency term excludes unobserved and time-invariant heterogeneity. In other words, on one hand, it is assumed that any structural inefficiency can be corrected during the sample period, so that persistent inefficiency is not included in the inefficiency term. And on the other hand, it is assumed that unobserved and time-invariant heterogeneity is captured by the frontier, and thus does not appear as inefficiency. Thus, all the and time-invariant effects are treated as unobserved heterogeneity, and are captured by the specific stochastic term of each region, $\alpha_{i.,}$ which is an *i.i.d* random component. This means that the random effects model has two major advantages: it controls for any omitted variable biases, and it avoids heterogeneity biases in the estimates of technical inefficiency.

The heterogeneity observed in u_{it} is taken into account with equation [4]. We include the efficiency determinants, z_k, as heteroscedastic variables in the inefficiency function. An advantage of this specification is that it lets us estimate the tax effort function simultaneously, as a one-step procedure, with the parameters of the stochastic frontier. This technique has an advantage over the alternative two-stage method where the first stage involves estimation of a conventional frontier model with environmental variables omitted, and the second stage involves regressing these predicted tax effort on the environmental variables. This procedure can lead to inconsistency in assumptions about the distribution of the tax effort since the estimates of *uit* will be biased by the omission of environmental variables in the first step regression. Thus, failure to include environmental variables in the first stage leads not only to biased estimators of the parameters of the deterministic part of the fiscal frontier but also to biased predictors of tax effort (see Subal C. Kumbhakar and Knox Lovell, 2000).

The results of estimating the model above, for which we took variables in logs and used the STATA statistical package, are shown in the second column of Table 2. As the estimator λ is significant and very high, the null hypothesis that γ equals 0 is rejected, and SFA is confirmed as a suitable method for the study - in other words, the need to include unrealised tax effort, u, in the tax capacity function. In fact, if we divide the variance of u by total variance, we obtain that 98.54% of the error term is due to unrealised tax effort. Additionally, the parameter of variance in non-observable heterogeneity (θ) is significant, which validates the Greene (2005) approach, in which the unobserved heterogeneity of municipalities must be separated from the inefficiency effects. The importance and significance of the variables explaining tax capacity (x_{it}) and the exercise of taxing power (z_{it}) also validate the suggested model.

The results are consistent with what we would expect from a theoretical point of view, and with the available but scanty empirical evidence (Pessino and Fenochietto, 2010, and Garg et al, 2017). It seems clear that the level of economic development (INCOME) and population (POP) play an important and direct role in explaining tax capacity, and that the suppression of Wealth Tax caused a reduction of regional tax potential in the 2009-2011 period. The model also shows the lower tax capacity of the Canary Islands (CAN), given the region's peripheral and isolated nature, its adverse climate and geographical conditions, and the scarcity of natural resources. The single-province regions (DPROV) enjoy greater tax potential, as they can use both provincial and regional revenues, although we have indicated that these regions also have higher spending needs because they take on the responsibilities of provincial governments. And finally, there is evidence of a growth trend (TEND) in tax potential, due to the passage of time and the learning process after the regions were given regulatory power over assigned taxes, especially from 2002.

The Driscoll-Kraay robust errors method (XTSCC), adapted by Daniel Hoechle (2007), produces similar coefficients to those of the SFA for estimating tax capacity, with an explanatory power of 97.64%. These results, which can be seen in the third column of Table 2, ratify the validity of the explanatory hypotheses of the stochastic frontier, and will serve as the basis for calculating tax effort with other, non-frontier methods.

Our SFA also supports most of the explanatory hypotheses of tax effort; many of the results are in line with the available theoretical and empirical evidence (Pessino and Fenochieto, 2010, and Garg et al., 2016). The variables which capture self-governance and the exercise of fiscal responsibility are decisive for the explanation of tax effort, as are the region's needs for non-financial expenditure (NFEXP). On the side of revenues, income from assets (PATREV) complements tax revenue, so that when there are budget tensions the regions behave consistently and responsibly, seeking both tax revenue and income from their assets, with no substitution effect between alternative income sources. However, the grants received (TRANSFREV) generate fiscal laziness in regions due to the fungibility effect; while financial spending, which reflects the size of the debt, is not significant, an aspect which is consistent with the strict budget balance restrictions on Spanish regions in recent decades.

Conversely, when the region presents a solid commitment to the exercise of its taxing power or a desire to collect taxes (ACTIVISM1 and ACTIVISM2), the margin of available unexploited tax revenue becomes narrower, i.e. its tax effort increases. The model also reveals that when the regional government is left-wing (dPOLITCOLOUR) it presents a less fiscally demanding taxation policy. However, it makes no difference if the same party is in government in the region and at the federal level (dSINT). The management inefficiency proxy (QMANAG) also lacks significance.

(Insert table 2 here)

A positive sign for the variable CRISIS shows that regional taxes have acted as automatic stabilisers, a result which is consistent with the economic recession and property market crisis, and with the progressiveness of income tax and its relative weight in the total tax revenue. Finally, the positive and significant coefficient of the variable DENSITY indicates that there are economies of scale in tax management and collection, linked to the concentration of the population.

After reviewing the results of the proposed econometric models (SFA and XTSCC), Table 3 presents the calculations of the tax effort obtained by comparing real tax revenue with the potential tax capacity found using these estimates. The first column in Table 3 shows that with SFA, the Spanish regions collected an average of 90.14% of their potential revenue, a result which demonstrates that in general, the tax behaviour of sub-central governments has been responsible. This allows us to refute the central government's repeated complaints that the regions are not responsible in tax matters. This result is similar to that of De la Fuente (2013), and Herrero and Martínez-Vázquez (2007), although it is far from the tax room to manoeuvre of Medina (2012) and López-Laborda (2015).

To check the robustness of our results, we also calculated tax effort with the Driscoll-Kraay robust errors method and with non-parametric frontier techniques (these latter do not allowing us to see the significance of the included variables): both partial frontiers (Order-m and Order-α), used to generate the explanatory variable of tax effort, ACTIVISM2; and the Free Disposal Hull (FDH), a non-convex version of DEA which is the basis for those partial frontiers. The results are presented in columns 3-6 of Table 3, and show that the average tax effort of the regions in the sample ranges from 86.09% to 106.6%, depending on the technique used to analyse it. This therefore confirms that hardly any tax room for manoeuvre margin is available, and reveals a highly responsible use of tax autonomy by the Spanish regions. As suggested by Oleg Badunenko, Daniel J. Henderson and Subal C. Kumbhakar (2012), the high value of λ could mean that both the SFA estimates and the non-parametric techniques are good, ratifying the similarity of the results.

However, all the cases show evidence of significant asymmetries between regions in the exercise of tax autonomy, reflecting the different territorial priorities at this level of government. Although some divergence can be seen in the results, depending on the analytical technique used, this disparity is due to the different approach underlying each method. In particular, the average behaviour approach (XTSCC) is very different from the frontier methods (stochastic or non-parametric), although these last are also slightly different, depending especially on whether they permit the presence of super-efficient units.

Leaving aside the average behaviour approach (XTSCC), which may be the most different from the rest, both in methodology and in results, we observe a clear consensus among all the frontier techniques used as to the jurisdictions making the greatest tax effort: Madrid, the Balearic Islands, Valencia, Andalusia, and Catalonia. There is slightly less agreement on the regions with the laziest tax behaviour, which we attribute to the inability of non-parametric frontier models to include dummy variables to control for the unique features of the institutions of each region. Murcia, Extremadura, and to a lesser extent Castilla La Mancha, would be the regions making the least tax effort, with some uncertainty regarding La Rioja. With the Driscoll-Kraay robust errors approach, which considers the average tax behaviour, La Rioja, the Balearic Islands, and to a lesser extent Extremadura are the regions making the highest tax effort (clearly above average), as López Laborda (2015) also concludes; while Castilla-La Mancha, Galicia, Castilla-León, and Murcia are making the least effort, in comparative terms. Medina (2012) identified Madrid (98%) and La Rioja (94%) as the only regions with a very high tax effort, while attributing a high capacity to increase revenue to the other regions, especially Andalusia (72%), Castilla-León (74%), Castilla- La Mancha (75%), and the Balearic Islands (76%).

(Insert table 3 here)

To analyse these tax discrepancies in more depth, we projected the situation of the Spanish regions in terms of tax effort, according to SFA, and per capita tax revenue, in Figure 1. This graph lets us classify the 15 Spanish regions in four groups, differentiating between regions with low per capita revenue because their tax effort is low (Extremadura, Murcia, and Castilla-La Mancha) and regions with low actual tax revenue but with high tax effort, because their tax capacity is limited (Andalusia, Valencia, Galicia, Castilla-León, and the Canary Islands). These last regions, located in zone II, have low per capita tax revenues, given their high tax effort. Note that all these jurisdictions with low per capita tax revenue (zones I and II) are those with the lowest per capita income. In contrast, the richer regions have high tax revenue and greater tax effort (Madrid, Catalonia, Balearic Islands, and Aragon), except La Rioja (zone I), which has enough margin to improve its tax collection quite significantly. At the same time, if we look at the situation in these regions in terms of debt, our results justify that regions like Catalonia and Andalusia with high tax effort opt for loans to meet their financing needs, but not regions like Extremadura and Murcia, with ample room to manoeuvre.

(Insert figure 1 here)

6. Final considerations

We calculated the tax effort of the Spanish regions using different techniques which have rarely been applied in this field, giving us mostly similar results. Thus, this work is contributing to introduce new methodologies in the empirical field, and also to improve the few available works on sub-central tax effort.

For the factors explaining potential tax revenue, the general indicators of tax capacity (income and population) are determinants, but the specific indicators (tax bases relating to assets and gambling) are not. The latter result may be associated with the explanatory power of the general indicators, or with the low quantitative weight of these types of taxes (wealth and gambling) in total revenue. The severe economic crisis, the temporary suppression of Wealth Tax, and the institutional differences between the regions (particularly in peripheral or single-province regions) are also relevant in the explanation of the tax frontier.

For tax effort, all the techniques confirms that the regions have exercised their tax responsibilities responsibly, so it looks like reasonable to refute the central government's complaints accusing the regional governments of irresponsible tax behaviour. The variables capturing financial autonomy and self-government ratify this conclusion. The greater tax effort made by the regions that want to support more or better non-financial current expenditure, the active commitment to tax collection of regional governments despite the severe restrictions on their taxing power, and the responsible use of complementary income sources, all clearly indicate an appropriate and serious exercise of their fiscal responsibility. The significance of population density demonstrates the existing differences in terms of scale economies in tax management and control. We have also found evidence that the design of the transfer system introduces perverse incentives, reducing the tax effort of the regions enjoying the largest grants. Tax effort was also reduced during Spain's severe economic crisis, revealing a countercyclical policy which has been considerably influenced by political ideology, although this result is also consistent with progressive taxation.

Results show asymmetries in the tax effort realised. Some jurisdictions (the poor ones) have a substantial margin for manoeuvre in taxation while others (usually more prosperous regions) are practically at the limits of the possibilities offered by the sub-central funding system. The construction of this map of tax effort lets us see that some regions have acquired debts despite having plenty of room to manoeuvre in terms of unexploited tax potential, and also despite being subjected to strict balanced budget restrictions. This reflects the problems of the system coordinating policies on loans, its faulty design, and the lack of penalties and suitable incentives, attested by the lack of a relationship between the financial burdens of the debt and the tax effort of the regions.

For all these reasons, a legal reform of the regional tax system to raise the tax frontier according to the principle of financial self-sufficiency seems to be necessary in the short term, in order to respond to the financial problems of regions that currently find themselves with no room for manoeuvre in terms of tax revenue, due to being very close to the tax frontier. For this purpose, it could be desirable to increase the regulatory powers of the regions; facilitate their access to new tax bases - their own or at other levels of government; or extend their tax space with types of taxes that are currently shared, such as personal income tax. This would make it possible to raise the potential tax revenue of all the regions and correct the endemic financial problems that have historically afflicted part of Spain's regional financial system, while leaving the final decision on how to use this potential in the hands of each region.

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Table 1: Taxes assigned to the Spanish regions, regulatory and management powers*

TAX	**ASSIGNED REVENUE**	**REGULATORY POWER**	**APPLICATION AND MANAGEMENT**
Wealth Tax (IP)	100%	Minimum exempt, tax rate, deductions and rebates.	Regional
Inheritance Tax (ISD)	100%	Rebates, tax rate, existing assets, deductions and allowances.	Regional
Estate and Property Transfer Tax (ITPAJD)	100%	Tax rate, deductions and rebates (except in IOS modality).	Regional
Gambling Taxes (TJ)	100%	Exemptions, tax base, tax rates and flat rates, accrued and allowances.	Regional
Personal Income Tax (IRPF)	50%	Regional tax rate and deductions, regional personal and family minimum (±10%)	Central
Value Added Tax (VAT)	50%	No, as required by the EU. Shared tax.	Central
Special taxes on alcohol and tobacco	58%	No, as required by the EU. Shared tax.	Central
Special tax on fuels	58%	Regional tax rates.	Central (Tax on retail sales of certain fuels: Regional)
Special tax on electricity	100%	No, as required by the EU. Shared tax.	Central
Tax on certain forms of transport (IDMT)	100%	Tax rates (+15%).	Regional

* Non-assigned taxes include Corporate Tax, Non-Resident Income Tax, Carbon Tax, tax on insurance premiums, etc.

Source: By the authors.

Table 2: Results of the estimates of tax potential

	SFA	XTSCC
Tax frontier		
INCOME	0.3140** 2.21	0.8307** 6.94
POP	0.3137** 5.11	-0.0557 -0.51
IP0911	-0.1633** -12.73	-0.2469** -4.02
CAN	-0.3349** -7.42	-0.3661** -10.30
DPROV	0.0511** 2.35	-0.0089 -0.38
STOCKP	0.2398 1.66	0.1839 1.70
GAMBLINGEXP	0.0264 0.49	0.0437 0.68
TEND	0.0412** 7.2	0.0506** 4.53
CONS	6.7913** 13.46	4.7971** 8.39
Tax Effort		
DENSITY	0.0016** 3.2	
POPGROWTH	-0.0064 -1.45	
QMANAG	0.0012 0.43	
TRANSFREV	0.0006** 3.98	
PATREV	-8.5545** -2.00	
ACTIVISM1	-0.2955** -2.58	
ACTIVISM2	-3.04E-06** -2.22	
dPOLITCOLOUR	0.1883* 1.84	
dSINT	0.0734 1.05	
NFEXP	-0.0007** -3.47	
CRISIS	0.6472** 3.23	
FEXP	-0.0004 -0.94	
CONS	0.5634 1.11	
θ	0.0896**	
σ_u^2	0.1737**	
σ_v^2	0.0213**	
λ (Ho: $\gamma = \sigma_u^2/\sigma_v^2 = 0$)	8.15007**	
R^2		97´64

(**) Significance at 1% and (*) at 5%.

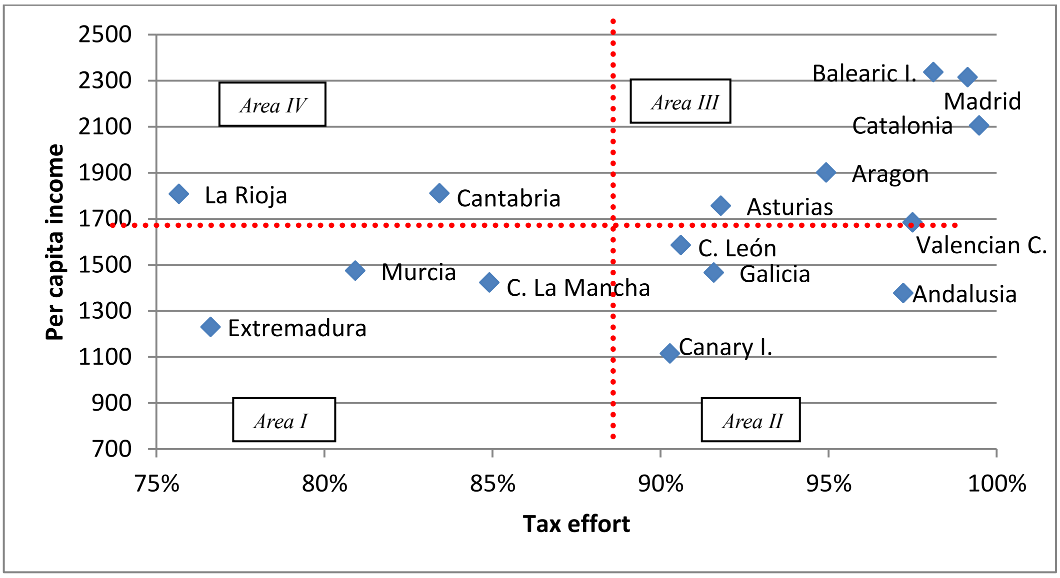
Table 3: Use of tax revenue capacity in Spanish regions

	SFA	XTSCC	Non-parametric frontier methods		
			Order-α(98)*	Order-m(160)*	FDH
Andalusia	0.9722	0.9757	1.3668	1.0350	0.9737
Aragon	0.9492	1.0661	0.8865	0.8302	0.8268
Asturias	0.9179	1.0939	0.8646	0.8648	0.8646
Balearic Islands	0.9812	1.2571	0.9488	0.9493	0.9488
Canary Islands	0.9027	1.0681	0.7017	0.6415	0.6319
Cantabria	0.8342	1.0550	0.8945	0.8945	0.8945
Catalonia	0.9948	0.9959	1.2137	0.9022	0.8471
Extremadura	0.7662	1.1238	0.8445	0.8448	0.8445
Galicia	0.9158	0.9214	0.9937	0.8750	0.8621
Castilla-León	0.9060	0.9506	1.0210	0.8067	0.7707
Madrid	0.9913	1.0163	1.5163	1.0693	0.9948
Castilla-La Mancha	0.8490	0.9145	0.9106	0.8234	0.8171
Murcia (Region of)	0.8092	0.9731	0.7594	0.7283	0.7242
Rioja (La)	0.7567	1.4991	0.9372	0.9372	0.9372
Valencian Community	0.9750	1.0830	1.3418	1.0360	0.9762
TOTAL	0.9014	1.0662	1.0134	0.8825	0.8609

* Although it does not appear in this document, we carried out a sensitivity analysis of the efficiency indicators, calculating the frontiers as m = 90, 120, … 200 and α = 90, 95, ... 97. These estimates make the presented results more robust and are available to readers on request.

Source: By the authors.

Figure 1: Tax effort (SFA) and collection per capita in the Spanish regions



Source: By the authors.

APPENDIX

Table A.1 Definition of the variables used and their sources

Variables	Description of the variable	Source of the information	Mean	Std. Dev.	Min	Max
DEATHS	Number of deaths in the region	National Statistics Institute (INE)	23512.13	18779.18	2615.90	67675.72
12w65	Total salaries from €12,000 to €65,000	By the authors, based on Job Market and Pensions in the Tributary Sources, Spanish Tax Agency (AEAT)	1.41E+10	1.29E+10	1.48E+09	4.80E+10
HOUSCON	Final household consumption of each region (in €)	Regional database of the Spanish economy BD.MORES (Ministry of Finance and Civil Service)	3.72E+10	3.43E+10	3.68E+09	1.16E+11
RICH	Total salaries over €150,000	By the authors, based on Job Market and Pensions in the Tributary Sources, Spanish Tax Agency (AEAT)	2.70E+09	4.11E+09	1.26E+08	1.76E+10
STOCKP	Stock of private capital	BD.MORES	1.82E+08	1.66E+08	1.66E+07	6.01E+08
HOUSEP	The average regional housing price per square metre	INE	1664413.00	489678.30	739037.40	3271030.00
IP0911	=1 in 2009-2011, when IP is not collected; = 0 otherwise		0.27	0.45	0.00	1.00
GAMBLINGEXP	Regional expenditure on gambling	INE	1.93E+09	1.68E+09	1.95E+08	5.53E+09
MORTGAGES	Number of mortgages issued	INE	74882.32	84220.36	1811.00	404875.00
FINACT	Financial assets	BD.MORES	1626469	2189477	75176	1.51e+07
TAX	Tax revenue of the region	General Secretary of Autonomic and Local Financing (Secretaria General de Financiación Autonómica y Local - SGFAL).	5.28E+09	5.19E+09	2.77E+08	2.06E+10
INCOME	Gross Domestic Product	BD.MORES	6.45E+10	6.15E+10	6.96E+09	2.17E+11
POP	Number of inhabitants	INE	2768.46	2388.63	279.36	8299.10
DPROV	=1 if the region comprises a single province: = 0 otherwise		0.33	0.47	0.00	1.00
CAN	=1 if Canary Islands, =0 otherwise		0.07	0.25	0.00	1.00
TEND	Trend variable		24.00	3.17	19.00	29.00
CRISIS	= 0 in 2007-12, =1 otherwise	INE	0.45	0.50	0.00	1.00
POLITCOLOUR	=1 if the region is governed by a left-wing party, =0 otherwise	Ministry of the Interior	0.39	0.49	0.00	1.00
DSINT	=1 if the central and regional governments are of the same party, =0 otherwise		.4969574	.5004986	0	1
ACTIVISM1	= tax effort for the regions that Order-α places beyond the frontier (Catalonia, Madrid, Andalusia, and Valencia), =0 otherwise	By the authors	0.40	0.73	0.00	3.39
ACTIVISM2	Per capita revenue from own taxes	SGFAL	19330.78	32795.91	0.00	160925.70
PATREV	(Income from assets + income from disposal of real investments)*1000/population	SGFAL	0.02	0.01	0.00	0.09
TRANSFREV	Per capita income from transfers	SGFAL	1463.28	835.79	-804.15	3244.38
NFEXP	Per capita current spending	SGFAL	2831.23	447.81	1537.60	4401.69
FEXP	Per capita current financial spending	SGFAL	133.601	147.3708	0	1412.031
DENSITY	Population /surface area	INE	154.64	178.04	22.34	798.02
POPGROWTH	(Final population - initial population)/initial population	INE	10.84	10.73	-6.48	33.17
QMANAG	Non-financial current income received/budgeted	SGFAL	101.43	12.05	80.33	148.57

Table A.2: Correlation matrix of variables

	INCOME	POP	IP0911	STOCKP	HOUSEP	DEATHS	GAMBLINGEXP	TEND	DENSITY	POPGROWTH	TRANSFREV	QMANAG	PATREV	ACTIVISM1	ACTIVISM2	NFEXP	CRISIS
INCOME	1																
POP	0.9524	1															
IP0911	-0.0058	0.0329	1														
STOCKP	0.9926	0.9670	0.0235	1													
HOUSEP	0.5632	0.3747	-0.0674	0.5005	1												
DEATHS	0.9131	0.9805	0.0059	0.9403	0.2752	1											
GAMBLINGEXP	0.9626	0.9496	-0.0799	0.9619	0.4683	0.9175	1										
TEND	0.0305	0.0455	0.7977	0.0321	0.1427	0.0103	-0.0669	1									
DENSITY	0.6204	0.4552	0.0285	0.5596	0.7193	0.3158	0.5734	0.0393	1								
POPGROWTH	0.1805	0.1197	-0.5231	0.1445	0.3492	0.0448	0.2654	-0.4196	0.2917	1							
TRANSFREV	-0.3722	-0.2386	-0.0738	-0.3335	-0.6346	-0.1456	-0.3633	-0.0830	-0.6520	-0.3998	1						
QMANAG	-0.0334	-0.0555	-0.3687	-0.0322	-0.0337	-0.0427	-0.0057	-0.5884	0.0026	0.2345	-0.0706	1					
PATREV	0.1302	0.1017	-0.3098	0.1270	-0.0301	0.1341	0.1320	-0.1879	0.1292	-0.1151	0.3001	-0.0034	1				
ACTIVISM1	0.9111	0.8912	0.0318	0.9051	0.4743	0.8373	0.8914	0.0543	0.5866	0.1973	-0.4459	-0.0165	-0.0119	1			
ACTIVISM2	-0.2611	-0.2590	0.0760	-0.2548	-0.0048	-0.3130	-0.2453	0.1329	0.0637	0.1164	0.0809	-0.0994	-0.1335	-0.2883	1		
NFEXP	-0.0475	-0.0240	0.2906	-0.0207	-0.1926	0.0308	-0.1336	0.3999	-0.3994	-0.3877	0.6416	-0.3637	0.1855	-0.1323	-0.0143	1	
CRISIS	0.0237	0.0297	0.5238	0.0245	0.1188	0.0060	-0.0102	0.5698	0.0254	-0.2221	0.1340	-0.3197	-0.0895	-0.0357	0.0651	0.4181	1

Table A.3: General and specific indexes of tax capacity
(Regressions using Driscoll-Kraay standard errors for the 2002-2012 period)

	Individual estimates (by taxes)							Aggregate estimate
	IP	ISD	ITPAJD	IRPF	VAT	IICCEE	Tjuego	Total tax revenue
Estimates of tax revenue using specific indicators of tax capacity								
DEATHS		5920.36 9.65						968.2755 0.02
12w60				0.00014 10.14				-.1202643 -0.91
HOMEXP					0.0368 14.43	0.02056 25.52		.0765143 2.04
RICH	2.52e-06 2.00							.0549367 0.92
STOCKP	0.3830 2.74							29.51556 2.86
HOUSEP	82.57 8.69	152.3004 16.28	337.6023 4.19					-178.8065 -0.61
ANUAL0911	-9.77 e+07 -7.97							-1.00e+09 -2.93
PLAYEXP							0.05295 7.63	-1.023991 -2.92
MORTGAGE			6976.109 6.21					1393.307 0.47
FINACT			0.08607 2.94					.1653496 1.21
CONS	-1.09+08 -3.20	-2.46e+08 -2.36	-5.65e+08 -3.63	-2.81e+08 -11.91	1.89e+07 1.34	4.99e+07 2.93	-3494809 -0.74	5.31e+08 0.85
R^2	0.6723	0.7607	0.8809	0.8253	0.8611	0.9128	0.6608	0,972
Estimates of tax revenue using specific indicators of tax capacity								
INCOME	.0034 4.11	.0042322 7.76	.0140434 4.85	.0409073 16.42	.0109878 5.23	.0028435 2.44	.0005747 0,753	0.07660 16.29
POPr	-54.21 -4.19	-47.69523 -4.61	-30.81779 -0.82	-275.2731 -3.64	251.4532 3.11	226.7382 7.54	29.94585 2.60	100.1408 0.59
CONS	1313950 -0.92	5607628 1.20	-5.19e+07 -1.81	-1.27e+08 -5.78	-1.68e+07 -0.71	4428533 0.49	3912222 1.50	-1.80+08 -4.16
R^2	0.60	0.8332	0.7123	0.8531	0.8597	0.9246	0.5659	0,955

Source: By the authors