A supply-demand model of the size of public sector and Wagner's law

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Abstract

In this paper, we develop a supply-demand model for the public sector, measured as governments' tax revenues divided by GDP. We use a political equilibrium with a rule of majority. The model takes into account inefficiencies caused by taxes and includes costs associated with public goods provision to consumers. We show that the size of the public sector depends on the median voter's income, size of population, costs associated with taxpaying, and quality of institutions, which reflect costs of public goods provision. The estimates for the OECD countries (2000-2017), using dynamic panel model techniques, are in line with the theoretical predictions; however, they do not confirm Wagner's law. Our estimates suggest that the size of the government sector grows as income increases, but at a slower rate. We show that the quality of institutions matters: a more effective government raises the share of public sector; better regulations, which permit and promote private sector development, reduce it.

JEL Classification: D72, H30, H41, I38, P43.

Keywords: Size of public sector; tax burden; median voter; Wagner's law; political equilibrium

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1 Introduction

The objectives of the public sector are to provide agents with public goods, perform redistributive policies, smooth economic cycles and set rules and regulations for the private sector. At an appropriate size and structure, the public sector can enhance agents' prosperity and economic growth, and as a consequence, academic researchers and policy makers closely study the determinants of optimality of size and structure. An important characteristic of government intervention in an economy is the tax burden. In this paper, we develop a supply-demand model for the tax burden with a political equilibrium based on the rule of majority. The model provides us with a theoretical approach for testing Wagner's law, which states that the share of public sector in an economy expands with economic growth (Wagner 1883; Wagner 1892). Our estimates for OECD countries do not confirm this law: although the absolute size of the public sector grows when income increases, its rate of growth is substantially lower than the growth of income. But, in general, the empirical estimates accord with our theoretical predictions.

There were no models to explain the determinants of the size of the public sector for a long time. Classical economists, such as Adam Smith put their efforts into descriptions of common long-lasting trends; however, no attempts were made to generalize observations into one theory (Tarschys 1975). The first simple theory to explain the size of the public sector was proposed by Adolph Wagner. He was the first economist who noticed a positive correlation between the level of economic development and the share of public sector. Wagner's law is still relevant nowadays. If, in a democratic country, Wagner's law is valid, this strengthens the theories expressed by Piketty (Piketty 2014; Piketty 2015), who noticed that economic growth leads to growing inequality and argued in favor of progressive taxes. If Wagner's law is not valid, it is worthwhile to find out why. One explanation could be that democratic regimes are not efficient in monitoring voters' preferences. If this is not the case, it could be that voters do not demand a larger share of public goods in their consumption. The later case would be a strong argument against economic populism, an approach which emphasizes income distribution and deemphasizes finance deficits and inflation (Dornbusch and Edwards 1990; Pereira and DallAcqua 1991).

There are numerous works devoted to testing Wagner's law. The main testing approach is based on an estimation of an econometric model and tests whether an increase in GDP per capita (or GDP) leads to an enlargement or subtraction of the public sector's share of the GDP. A number of works confirm the law (Lamartina and Zaghini 2011; Magazzino, Giolli, and Mele

2015; Atasoy and Gür 2016), the others do not (Moore 2016; Afonso and Alves 2017; Funashima and Hiraga 2017; Jalles 2019). An analysis of very long time series for Sweden and the UK reveals that Wagner's law was valid between roughly 1860-1970, but does not support the law for the periods before 1860 and after 1970 (Durevall and Henrekson 2011). By contrast, Italian data suggest that Wagner's law for aggregate expenditure was valid for the second half of the 19th century only (Pistoresi et al. 2017).

Economic growth may also affect the structure of government expenditures. The usual result is that a few types of government expenditures, such as capital formation, rise more than proportionally as the economy grows, while the share of most other expenditures declines (Courakis et al. 1993, Chletsos and Kollias 1997, Akitoby et al. 2006, Magazzino 2012). The tax composition of governments' revenues changes as well (Mahdavi 2008).

A number of economists contrast Wagner's law to the theories of Keynes, who claimed that government expenditures can serve as a policy tool, and, hence, are exogenous. Therefore, a number of works test Granger causality between government expenditures and economic growth (Berry and Lowery 1987; Katrakilidis and Tsaliki 2009; Irandoust 2019; Sedrakyan and Varela-Candamio 2019). The results are mixed, but most works find that causality runs from economic development to government expenditures.

A large strand of literature focuses on other determinants of the size of the public sector. One of the first in this field was Hinrichs (1965), who argued that the most important determinant of the tax burden on the economy is its openness (imports share to GDP). Empirical estimates suggested that openness was very important for poor countries, while economic growth weakened this link. These results were updated by Shin (1969), who reported the significant influence of both the openness of economies and GNP per capita, population growth and the degree of industrialization. Other works of that period studied either the impact of various indicators of economic development, such as income per capita and a share of agriculture in GDP, or structural variables which affect the size of the tax base. Nevertheless, Weiss (1969) emphasized that apart from purely economic determinants, social, political and cultural aspects affecting agent's readiness to pay taxes should also be considered. Kelley (1976) stressed the role of demographic factors: population size and density, and age structure. Population size affects the relative size of the public sector via economies of scale, and diseconomies of scale arising from congestion and the rising costs of communication. Similarly, the structure of the population affects the size of the public sector via shifting the demand for public goods and services toward the needs of the relatively expanding age cohorts.

One of the first works that applied a complex approach to the determinants of the size of the public sector was that of Chenery et al. (1975). The main goal of their work was to find common indicators for all countries that affect the structure of economies. They noted that as income grows the tax burden on the economy is more affected by the demand for public goods and political preferences than the limits of the tax base and the need to balance the budget.

Nowadays, empirical research focuses on combinations of factors affecting demand and supply of public goods. For example, Mahdavi (2008), with data for developing countries, studied a wide range of explanatory variables which affect demand for public goods such as population structure and education. The supply side was represented by the level of corruption, political regime and a number of proxies capturing the costs of tax collection. Bird et al. (2014) analyzed supply and demand sides for public sectors in developing countries too but focused on the quality of institutions. They concluded that reliable political institutions increase the supply of public goods, raising agents' willingness to pay taxes.

The size of the public sector was also extensively studied from a formal 'mathematical' modeling perspective. Early works in this field looked for optimal quantities of public goods and realistic tools for finding optimality (Samuelson 1954; Lindahl 1958). These works created a formal analytical framework to model the demand for public goods and the main concepts - the concept of public goods referring to pure non-excludable public goods. The concept was generalized by Ellickson (1973) who allowed for their overuse or crowding. A general-equilibrium framework, which allows for public projects with no linear or ordered structure, was proposed by Mas-Colell (1980) who developed welfare theorems to the model with one private good and a finite number of agents. The results were extended by Diamantaras and Gilles (1996), who introduced many private goods to the model, and De Simone and Graziano (2004), who generalized these results for an infinite-dimensional space of private goods.

In our paper, we introduce a political equilibrium to the Mas-Colell model. We develop a model with one public and one private good and include voting under majority rule. The result is a demand-supply model for public goods, with an equilibrium determined by the median voter's preferences, size of population, and a number of institutional factors affecting demand and supply of public goods.

Our empirical model focuses on the dynamics of developed (OECD) countries. It allows for frictions in adjusting the level of public sector and includes country-specific effects, which solve endogeneity problems arising from time-invariant omitted variables, such as different geographical location, history and culture. Our results do not confirm Wagner's law and emphasize the quality of institutions. In contrast to Bird et al. (2014) our estimates suggest that better institutions may reduce the share of the public sector, if they promote development of the private sector.

2 Model

2.1 Demand for public goods

Suppose there are N agents in the model. Every individual i, $i = 1, ..., N$, maximizes her utility function $U_i(\cdot, \cdot)$, which depends on consumption of private (X_i) and public (G) goods. We assume that the utility function is strictly increasing and concave in both arguments. Public goods are non-excludable and their amount is the same for all individuals; however, individuals' private utilities may decline with the number of other individuals who consume these public goods. We assume that public goods enter the utility function as $GN^{-\alpha}$, where $\alpha \in [0, \infty)$ is the parameter, which reflects the crowding effect.

The consumers' optimization problem is:

$$\max_{X_i, G} U_i(X_i, GN^{-\alpha}), \tag{1}$$

$$X_i + \tau_i G = Y_i, \tag{2}$$

where Y_i is individual gross income; τ_i is the tax burden (in terms of private goods) agents pay for one unit of public goods, $0 < \tau_i G < Y_i$. From the individual's point of view, τ_i is fixed and determined by the government. It includes tax compliance costs, such as time spent for taxpaying. We assume that compliance costs τ_i^{comp} are proportional to taxes to be paid τ_i^1: $\tau_i^{comp} = f(I^d)\tau_i^1$. I^d reflects the quality of institutions, which determine the tax system's simplicity, such as time used to pay taxes. We suppose that a larger I^d corresponds to better institutions, and $f'(\cdot) < 0$.

$$\tau_i = \tau_i^1(1 + f(I^d)). \tag{3}$$

The total sum of private taxes, which are used for public goods financing, are equal to the price of one unit of public goods (p^G):

$$\sum_{i=1}^{N} \tau_i^1 = p^G. \tag{4}$$

Solving the optimization problem (1-2), agents receive the following individual demand function for public goods:

$$G_i^d = G_i^d\Big(\overset{+}{Y_i}, \overset{-}{\tau_i}, \overset{-}{N} \Big). \tag{5}$$

The individual demand function depends positively on the first argument: an increase in agent's income raises demand for public goods. The impact of the second argument is negative: a higher price for public goods reduces demand. The impact of the third argument is also negative as public goods are shared with a larger number of people (crowding effect).

We assume that the society consists of individuals with different preferences, incomes and gross taxes, which are set by the government. Likewise, the desired quantity of public goods is determined by a specific procedure of public choice, by our assumption, majority rule.

The assumption about the utility function's strict concavity implies that the solution of agents' optimization problem (5) is unique and single-peaked. Furthermore, the choice of the size of the public sector is a one-dimensional problem. Therefore, according to the median voter's theorem, the equilibrium amount of the public sector is determined by the voter with the median net income (see Mueller 2003, section 5.3 for a formal proof). We also assume that $d\tau_i/dY_i < 1$: the median voter also obtains the median gross income. This condition ensures that agents who receive higher gross income also receive higher net income. For simplicity, we also assume that all individuals pay the same taxes for one unit of public goods: $\tau_i^1 = N^{-1}p^G$, $i = 1, ..., N$, then the demand for public goods is characterized by:

$$G^d = G^d\Big(\overset{+}{Y_m}, \overset{-}{\frac{p^G(1+f(I^d))}{N}}, \overset{-}{N} \Big), \tag{6}$$

where subtitle m corresponds to the median voter. The demand for public goods increases with the median voter's income, and declines with their costs. The impact of the third argument is negative; however, the total impact of N is unknown because N also affects the second argument of the function. Furthermore, variations in population size may also alter the median voter and Y_m, as a consequence.

2.2 Supply of public goods

Total government expenditure on public goods depend on population size. The outlay is of two parts: direct costs of producing or purchasing public goods (C_d), and their provision to consumers. We suppose that total costs are equal to $C = g_1(I^s)C_dN^\gamma$, where $g_1(\cdot)$ is a function $g_1'(\cdot) < 0$, I^s denotes institutional factors, which affect total costs of public goods from the supply side. I^s may be considered as the capability of government personnel, complexity of bureaucratic procedures, corruption, expenditures for auditing and prevention of tax evasion. Higher values of I^s are associated with better institutions and lower costs. Larger population size N increases the total costs ($\gamma \geq 0$) due to more costly public goods provision to consumers.

We suppose that the government employs labor and capital for public goods production. Alternatively, it may buy these goods from private firms. The production costs can be written as:

$$C_d = \sum_{j=1}^{J_1} w^j L^j + \sum_{j=1}^{J_2} r^j K^j, \tag{7}$$

where summation is made across all production factors L^j (labor), K^j (capital); w^j and r^j denote factor costs. We assume that they are exogenous. The analog of the production function is:

$$G = g_2(I^s)F(L^1...L^{J_1}, K^1...K^{J_2}), \tag{8}$$

where $g_2(\cdot)$, $g_2'(\cdot) > 0$ is a function which accounts for the quality of institutions I^s, which characterise government efficiency. $F()$ is a usual neoclassical production function. The government minimizes the total costs of production under the constraint that $G \geq G_0$, where G_0 is the necessary amount of public goods.

$$\min_{L^j, K^j} g_1(I^s)\left(\sum_{j=1}^{J_1} w^j L^j + \sum_{j=1}^{J_2} r^j K^j\right)N^\gamma, \tag{9}$$

$$g_2(I^s)F(L^1...L^{J_1}, K^1...K^{J_2}) \geq G_0. \tag{10}$$

Denote the solution of this optimization problem as:

$$C = C(\overset{-}{I^s}, \overset{+}{G_0}, \overset{+}{N}) \tag{11}$$

An improvement in the quality of institutions brings a decline in the total costs of public goods. Total costs rise with an increased quantity of public goods and an increase in population size. The costs are financed by taxes $C(\overset{-}{I^s}, \overset{+}{G_0}, \overset{+}{N}) = G_0 p^G$, or

$$p^G = \frac{C(\overset{-}{I^s}, \overset{+}{G_0}, \overset{+}{N})}{G_0} = P_s(\overset{-}{I^s}, \overset{?}{G_0}, \overset{+}{N}). \tag{12}$$

Under decreasing returns to scale in production, $C(I^s, G_0, N)$ is convex in G_0. In this case, the price of one public good p^G increases in G_0. The opposite holds if returns to scale are increasing. Under constant returns to scale, p^G does not depend on G_0. Better institutions I^s reduce the costs of public goods production, and, hence, reduce the gross tax rate p^G.

2.3 Equilibrium

Equations (6) and (12) can be solved for equilibrium values of G and p^G. Denote them as G_{eq} and p^G_{eq}:

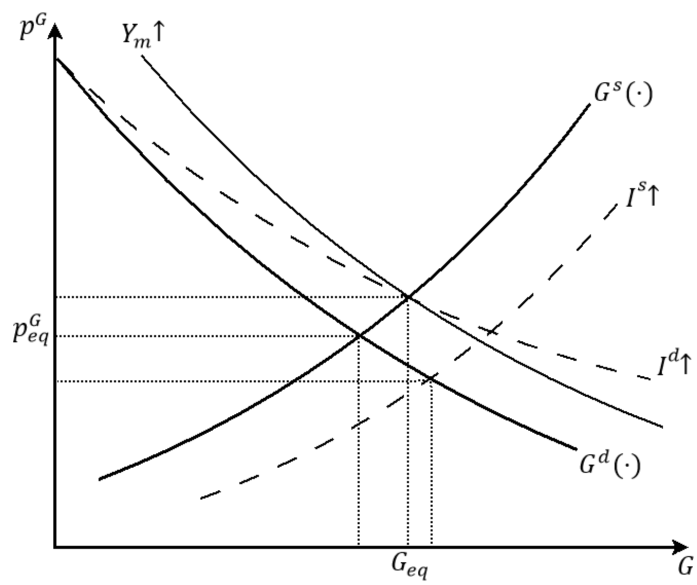
$$G_{eq} = G_{eq}(\overset{+}{I^d}, \overset{+}{I^s}, \overset{+}{Y_m}, \overset{?}{N}) \tag{13}$$

$$p^G_{eq} = p^G(\overset{+}{I^d}, \overset{-}{I^s}, \overset{+}{Y_m}, \overset{?}{N}) \tag{14}$$

First, assume decreasing returns to scale in production function. Figure 1 depicts demand and supply curves. A higher median voter's income Y_m makes public goods more affordable for the median voter, shifting the demand curve up. This raises both the quantity of public goods (G_{eq}) and their price per unit (p^G_{eq}). When the quality of institutions from the demand side improves (I^d grows), the demand curve turns upwards around its intersection point with the vertical axis. This effect is determined by the fact that for every fixed level of G, the gross tax (including costs associated with tax paying) for the median voter declines. Hence, the median voter can afford more public goods. The price per unit grows as well. An improvement in the quality of institutions from the supply side (an increase in I^s) shifts the supply curve down, as more public goods can be produced at lower costs. This results in an increase in G_{eq} and a decline in p^G_{eq}.

The impact of population size N is not clear in that N is present in the second argument on the left side part of equation (6). A larger population leads to an overuse of public goods, and also increases the tax base. As a result, the total effect of N on the demand curve is ambiguous.

Figure 1: Demand and supply curves: decreasing returns to scale



The effects of I^d, I^s, Y_m and N were explained under the assumption of decreasing returns to scale in public goods production. Under constant returns to scale, the supply curve becomes horizontal. In this case, G_{eq} behaves as in the case of decreasing returns to scale, but shifts in the demand curve do not affect p^G_{eq}. An improvement in I^s is analogous to the case with decreasing returns to scale.

Under increasing returns to scale, the supply curve declines in G. If we assume that it is flatter than the demand curve, G_{eq} behaves similarly to the case with decreasing returns to scale; however, the effects of changes in I^d and Y_m on p^G_{eq} are the opposite. This can be seen from Figure 2 in the appendix.

2.4 Share of taxes in total income

Equation (13) expresses the quantity of public goods; equation (14) describes their price per unit in terms of collected taxes. Multiplying one equation by the other, we receive an equation for the total amount of taxes collected for public goods financing:

$$TAX^{eq} := p_{eq}^{G} G_{eq} = TAX_{eq}(\overset{+}{I^d}, \overset{?}{I^s}, \overset{+}{Y_m}, \overset{?}{N}) \tag{15}$$

Better institutional quality I^d increases the total taxes under the assumption that returns to scale are nonincreasing. If they are increasing, the total impact is not clear (see equations (18-19) in the appendix). The impacts of I^s, Y_m and N follow directly form equations (13) and (14).

In order to receive an equation more convenient for econometric analysis, we divide equation (15) by $N\bar{Y}$, where $\bar{Y}$ denotes an average income in the population. Therefore, $N\bar{Y}$ denotes total income received by agents in the country. Having assumed that there is a direct link between the average income and the income of the median voter $Y_m = \psi(\bar{Y})$, where $\psi(\cdot)$ is a strictly increasing function we receive:

$$\frac{TAX^{eq}}{N\bar{Y}} := TAX_{share}(\overset{+}{I^d}, \overset{?}{I^s}, \overset{?}{\bar{Y}}, \overset{?}{N}). \tag{16}$$

The left side of equation (16) denotes the share of taxes in total income. This expression allows us to use the share of taxes in the GDP in the empirical analysis.

3 Empirical analysis

3.1 Data

We analyze cross-country data of OECD countries (36 countries in total) collected from two sources: World Bank Development Indicators (WBDI) and Worldwide Governance Indicators (WGI). The data range is 2000-2017.

Our dependent variable is tax revenue (percent of GDP). According to its definition "tax revenue refers to compulsory transfers to the central government for public purposes. Certain compulsory transfers such as fines, penalties, and most social security contributions are excluded. Refunds and corrections of erroneously collected tax revenue are treated as negative revenue." We focus on the central government's tax revenues. Studying regional taxation would require a completely different regional data analysis to account for the peculiarities of specific regions.

We approximate the median voters' income in the following way: first, we multiplied the income share held by the third 20 percent of the population[3]

[3] This data are provided by WBDI.

Table 1: Descriptive statistics

variables	mean	S.D.	min	max	Source
TAX/GDP	19.17	7.066	1.230	38.519	WBDI
Median voter's income	32305.9	20133.37	533.422	95173.1	WBDI, own calculations
GDP per capita	36698.23	21843.87	6933.6	111968.3	WBDI
Gini	32.448	5.397	23.7	52.8	WBDI
Time to pay taxes	188.87	99.92	50	866	WBDI
Population	34,194,738	56,016,500	281,205	325,719,178	WBDI
Dependency ratio	49.766	5.206	36.323	66.487	WBDI
Government effectiveness	1.3089	0.5574	-0.03	2.35	WGI
Regulatory quality	1.2810	0.4389	0.04	2.1	WGI
Control of corruption	1.2543	0.7996	-0.93	2.47	WGI

and GDP in constant prices, receiving the total income held by the third 20 percent of the population. Dividing this income by the corresponding number of people, we receive an average income obtained by the third 20 percent of the population. The resulting values are used as a proxy for the median voter's income.

In our models we also use the following variables which reflect demand for public goods: GDP per capita in 2010 prices, the Gini coefficient, time to prepare and pay taxes (hours), population size and dependency ratio. Dependency ratio is defined as the ratio of dependents - people younger than 15 or older than 64 - to the working-age population.

The supply side reflects the quality of institutions. It includes government effectiveness. It is defined as "the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies." The second variable is regulatory quality, which is defined as the "ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development." The third variable is control of corruption, which by definition "reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.". Theoretically, these variables have a range between -2.5 and 2.5. Higher values of these variables correspond to better institutions. Variables used in our analysis are summarized in table 1.

The data constitute an unbalanced panel. Median voter's income and the Gini coefficient contain many missing observations. WGI variables on the quality of institutions contain a number of missing observations as well.

3.2 Methodology

We estimate a dynamic panel model with fixed individual effects, applying the usual Arellano-Bond estimator (Arellano and Bond 1991). We use four lags of the dependent variable as instruments. The dynamic lagged variable has an economic interpretation. It reflects frictions in adjusting public policies. It is known that agents, including the median voter, often prefer the status quo (Kahneman, Knetsch, and Thaler 1991; Brooks and Manza 2008; Elmelund-Præstekær and Emmenegger 2013). An inclusion of the lagged dependent variable into the model takes such behavior into account.

Our theoretical model is static, but before making empirical estimations we consider time indexes. Government budgets are usually planned in advance following economic development forecasts. State revenues and expenditures for a specific year are usually set by parliaments before the year begins. Therefore, it is wise to consider a model in which the share of taxes in GDP at time t is determined by explanatory variables at time $t-1$ - the period corresponding to the calendar year. For example, the functional form can be the following:

$$\log\left(\frac{TAX^{eq}_{i,t}}{N_{i,t}\bar{Y}_{i,t}}\right) = \beta_{0,i} + \gamma\frac{TAX^{eq}_{i,t-1}}{N_{i,t-1}\bar{Y}_{i,t-1}} + \beta_1 I^d_{i,t-1} + \beta_2 I^s_{i,t-1} + \beta_3 \log\bar{Y}_{i,t-1} + \beta_4 \log N_{i,t-1} + \varepsilon_{i,t}. \quad (17)$$

where i is a country-specific index, $\beta_{0,i}$ - country-specific fixed effects. On the right hand side of equation (17) we use logarithms of income and population size. We also take a logarithm of time spent for taxpaying. The log-log functional form simplifies the interpretation of the coefficients: If $\beta_3 > 0$, the Wagner's law is confirmed. The case $-1 < \beta_3 < 0$ indicates that public goods are normal goods, while $\beta_3 < -1$ corresponds to the case of inferior public goods. An inclusion of lagged explanatory variables into the model solves a number of endogeneity problems and allows us to refer to Granger causality (Granger 1969).

We expect that the coefficient corresponding to the median voter's income is positive, because such a coefficient would correspond to Wagner's law. However, a negative coefficient is also in line with our theoretical model (16). If the median voter's income is replaced with GDP per capita and the Gini coefficient, we expect a positive coefficient for GDP per capita (Wagner's law), and a negative for the Gini coefficient, since greater inequality reduces the median voter's income.

More time spent for taxpaying is likely to reduce demand for public goods, because it is associated with additional costs, while the effect of population size is unknown. On one hand, larger population size is associated with crowding and higher provision costs, on the other, it gives rise to lower per capita costs for public goods. We also control for the dependency ratio and expect that a higher dependency ratio positively affects the size of the public sector, due to a higher demand for redistributive policies. More reliable governmental institutions increase demand for public goods, but reduces their price. Therefore, the overall effect of the variables "government effectiveness", "regulatory quality" and "control of corruption" is ambiguous.

3.3 Results

Table 2 presents estimates of equation (17) when the logarithm of the median voter's income is included as an explanatory variable. In the first model, we also control for the logarithm of time spent for taxpaying. In the second model, we add the logarithm of population size. The third model includes the dependency ratio. In models 4-6 we include factors which reflect the quality of institutions: government effectiveness, regulatory quality and corruption.

A higher median voter's income reduces the size of the public sector, with the corresponding coefficient always significant at the 10% significance level. A 1 percent increase in the median voter's income corresponds to a 0.12-0.14 percent short-run decline in the relative size of the public sector. As in the dynamic panel models, changes in the explanatory variables also have an influence via the lagged dependent variable; it is possible to show that a permanent 1 percent increase in the median voter's income will lead to a 0.23-0.42 percent decline in the size of the public sector in the long run.[4] A higher dependency ratio increases the size of the public sector due to increasing demand for redistributive programs. A one point increase in the dependency ratio corresponds to approximately a 0.6-0.8 percent short run increase in the size of the public sector. The long run effects are estimated to be slightly higher than 1 percent.

In models 5 and 6, government effectiveness and regulatory quality are significant at reasonable significance levels. The more effective the government, the more public goods agents empower the government to produce, while better regulatory quality reduces the share of the public sector by enabling a larger private sector role. The coefficients corresponding to the time spent on taxpaying, size of population and control of corruption are insignificant at 10 percent significance level.

[4] In model 1, for example, the long run effect can be obtained as -0.1437/(1-0.6545)=-0.4159.

Table 2: Dependent variable: log(TAX/GDP), fixed country-specific effects, median voter's income

regressors	1	2	3	4	5	6
log(TAX/GDP)$_{t-1}$	0.6545***	0.6481***	0.4497***	0.4533***	0.4718***	0.4707***
	(0.0850)	(0.1067)	(0.1007)	(0.1025)	(0.1022)	(0.1009)
log(median income)$_{t-1}$	-0.1437**	-0.1219*	-0.1448**	-0.1430**	-0.1256*	-0.1255*
	(0.0729)	(0.0727)	(0.0649)	(0.0657)	(0.0663)	(0.0660)
log(Time for taxes)$_{t-1}$	-0.0282	-0.0655	0.0057	0.0040	0.0103	0.0103
	(0.0269)	(0.0421)	(0.0266)	(0.0267)	(0.0244)	(0.0237)
log(Population)$_{t-1}$		-0.3933	-0.4855	-0.4178	-0.3972	-0.3979
		(0.2877)	(0.3430)	(0.3452)	(0.3263)	(0.3302)
Dependency$_{t-1}$			0.0064**	0.0080**	0.0076**	0.0076**
			(0.0032)	(0.0033)	(0.0035)	(0.0035)
Government effectiveness$_{t-1}$				0.0421	0.0594**	0.0593**
				(0.0318)	(0.0276)	(0.0262)
Regulatory Quality$_{t-1}$					-0.0602*	-0.0601**
					(0.0324)	(0.0372)
Control of corruption$_{t-1}$						0.0005
						(0.0361)
Sargan test	0.7963	0.7644	0.9906	0.9902	0.9908	0.9909
AR(1) p-value	0.0006	0.0005	0.0085	0.0109	0.0071	0.0095
AR(2) p-value	0.4715	0.4805	0.4681	0.4363	0.4876	0.4882
N	246	246	246	246	246	246

* $p < 0.1$
** $p < 0.05$
*** $p < 0.01$ significance level

In table 3, we present estimates of the model when the median voter's income is approximated by more usual variables: GDP per capita in constant prices and the Gini coefficient. The negative effects of the GDP per capita are estimated to be larger than those with the median voter's income; however, the Gini coefficient has no significant impact.

The major difference between the results presented in table 3 and those in table 2 is that population size, which has a negative sign, became significant in models 2-3 and 5 at the 10% significance level. In model 2, reported in table 3, time spent on taxpaying is significant at the 10% significance level: more time required to pay taxes reduces the size of the public sector. However, when more variables are controlled for, the regressor loses its significance.

4 Discussion and conclusions

In this paper, we developed a supply-demand model for the public sector with political equilibrium, determined by simple majority voting. The equi-

Table 3: Dependent variable: log(TAX/GDP), fixed individual effects, GDP and Gini coefficient

regressors	1	2	3	4	5	6
log(TAX/GDP)$_{t-1}$	0.6243***	0.5965***	0.4584***	0.4672***	0.5421***	0.4860***
	(0.0984)	(0.1195)	(0.1245)	(0.1240)	(0.1072)	(0.1228)
log(GDP/capita)$_{t-1}$	-0.1940*	-0.1699*	-0.1595**	-0.1619**	-0.1447**	-0.1427**
	(0.1040)	(0,0952)	(0.0778)	(0.0763)	(0.0661)	(0.0696)
Gini$_{t-1}$	0.0027	0.0030	0.0028	0.0029	0.0030	0.0034
	(0.0052)	(0.0053)	(0.0051)	(0.0052)	(0.0052)	(0.0053)
log(Time for taxes)$_{t-1}$	-0.00231	-0.0676*	-0.0050	-0.0085	-0.0110	-0.0001
	(0.0282)	(0.0404)	(0.0321)	(0.0032)	(0.0334)	(0.0282)
log(Population)$_{t-1}$		-0.5238*	-0.6054*	-0.5316	-0.4519*	-0.5090
		(0.3135)	(0.3454)	(0.3474)	(0.2690)	(0.3263)
Dependency$_{t-1}$			0.0073*	0.0070*	0.0052	0.0063
			(0.0032)	(0.0040)	(0.0039)	(0.0043)
Government effectiveness$_{t-1}$				0.0421	0.0496*	0.0608**
				(0.0322)	(0.0284)	(0.0281)
Regulatory Quality$_{t-1}$					-0.0443	-0.0545*
					(0.0378)	(0.0321)
Control of Corruption$_{t-1}$						-0.0117
						(0.0371)
Sargan test	0.9844	0.9859	0.9861	0.9861	1	0.9796
AR(1) p-value	0.0026	0.0032	0.0087	0.0103	0.0046	0.0074
AR(2) p-value	0.376	0.375	0.3576	0.3345	0.3794	0.3742
N	252	252	252	252	252	252

* $p < 0.1$
** $p < 0.05$
*** $p < 0.01$ significance level

librium size of the public sector depends on the median voter's income, population size and the quality of institutions which affect demand for public goods and their supply. This theoretical model allows us to test Wagner's law in a supply-demand framework.

Our estimates do not confirm Wagner's law for the OECD countries: the government share in the economy declines with income. This effect is lower if income is measured as the average income of the third 20% of population and larger if it is measured as GDP per capita. Nevertheless, public goods are normal goods, and their demand increases with income. In a number of models, the size of the public sector increases in the dependency ratio: a larger share of agents of nonworking age (youth and pensioners) requires higher redistribution. The impact of time spent on taxpaying is negative: it increases the costs of public goods and reduces their demand. As a consequence, the size of the public sector declines. However, this result is not robust because the corresponding coefficient is insignificant in most of the models.

A larger population leads to an overuse of public goods (crowding effect) and increases provision costs; it raises their price and leads to a fall in demand. Furthermore, a larger population size increases the tax base and leads to lower per capita costs. Our estimates suggest that a reduction in demand dominates the other effects, the overall effect of population on the size of the public sector being negative. However, the resulting coefficient is insignificant in a few model specifications.

The quality of institutions has diverse effects on the size of the public sector: a more effective government measured by the quality of public and civil services heightens demand for public goods and increases the size of the public sector. Better regulatory quality, associated with better regulations that permit and promote private sector development, has the opposite effect. Our estimates reveal no significant effect of the control of corruption. It is likely that better corruption control reduces the price of public goods and has a negative impact on the size of the public sector, while an increased demand affects the size of the public sector in the opposite way. The sum of these two effects is statistically indistinguishable from zero.

Our model addresses current trends in an attempt to explain them. The results may be taken into account by policy-makers for the development and implementation of policy reforms. For example, chapter 3 of the European Pillar of Social Rights in 20 principles proposes a drastic increase in social protection and inclusion. The implementation of these principles is associated with a significant growth in public sector. Our estimates suggest that such an increase should be accompanied by economic growth. An increase in the public sector relative to income may harm political equilibrium, however, and cause a new wave of euro-skepticism, while a gradual implementation of the principles supplemented by faster economic growth may garner more public support.

In the future, our theoretical model can be expanded by endogenous income and labor supply, which depend on tax rates, and, as a consequence, on the size of the public sector. A research agenda can also focus on the demand for redistributive policies, poverty reduction and risk sharing and investigate if similar effects can be found in developing countries: CIS, MENA, Latin America, Southeast Asia, Sub-Saharan Africa. Such estimates may depict a broader picture of Wagner's law's applicability and reveal other factors that affect the size of the public sector. The usage of a lower level of aggregation also seems to be promising.

Conflict of interest

The authors declare that they have no conflict of interest. The work was not supported by any grant apart from the authors' regular salaries in their institutions.

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Appendix 1

$$G_{eq} = G_{eq}(\overset{+}{I^d}, \overset{+}{I^s}, \overset{+}{Y_m}, \overset{?}{N}) \tag{18}$$

$$p^G_{eq} = p^G(\overset{-}{I^d}, \overset{-}{I^s}, \overset{-}{Y_m}, \overset{?}{N}) \tag{19}$$

Figure 2: Demand and supply curves: increasing returns to scale