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Does political alignment across government tiers impact the provision of public services? A case from the water sector of Peru

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***Abstract*---**This study analyzes the impact of political alignment on the performance of public utilities in a decentralized government structure. The literature shows decentralization improving the provision of public services because local authorities are better informed of local needs when making funds allocation. Yet, political interference in the decision making of service providers may undermine this effect. The Peru water sector is ideal for investigating the issue because the country has a decentralized structure and the water utilities' boards of directors are selected by local political authorities. Political variables are constructed from the results of elections in 2002 and 2006 to capture alignment between the two lower government tiers, municipalities and regions. Results show that the utilities' cost increased in 2006 when there was a larger share of municipalities and regions politically aligned than in 2002. This suggests that cost inefficiencies may cancel out service improvements from decentralization. When investigating the alignment to central government in 2006, when APRA was its ruler, results show a puzzling change in sign that warrants further investigation. In conclusion, this study provides information relevant to policy makers and regulatory authorities involved with the water sector, and to stakeholders related to the provision of public services.

***Keywords*---**political interference, decentralization, municipalities, stochastic frontier analysis, water sector
JEL Classifications : L95, D22, C51

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1. Introduction

As early as Oates (1972), the literature on government decentralization shows improvement of the provision of public goods and services. This improvement comes about because the administrative decision-making process is closer to local service needs allowing local officials to be better informed when allocating funds. At the same time some studies give cause for concern to political factors after decentralization. For instance, Herrera and Post (2014) find that the citizen participation increase resulting from decentralization makes it difficult for service providers to avoid political interference. The authors argue that less rather than more political interference allows service providers to adopt revenue and collection policies that generates a larger share of revenue from consumers, rather than being budget dependent on politically influenced government funds.

This study extends Herrera and Post (2014) by investigating the impact of political alignment on service provision in Peru's water sector. This country is ideal for this analysis because the water service utilities are politically connected to local governments: local political leaders elect the utilities' boards of directors. My focus in the analysis is on the utilities' operating costs. I hypothesize that political interference affects decisions regarding operating costs such as selecting input resources and/or their amounts with a direct impact on cost efficiency, increasing or decreasing costs.

Crucial in my analysis is the role of political (party) alignment across the decentralized tiers, in Peru they are municipalities and regions. The main point is that political favoritism may lead to higher costs. For example, poor labor decisions, such as hiring more workers than optimal to keep popularity with labor unions, or by making poor capital decisions by expanding a network to a municipality where leaders are aligned to the same political party.

I assume that the larger the number of municipalities politically aligned to the regional leader, the higher would be their bargaining power when asking for resources to the regional leader. At the same time, this political alignment could give the regional government higher leverage allowing them to influence utilities' operational decisions and directly affecting costs. I am not disentangling these two possible effects in the analysis and assume that they work together to impact the utilities' operating costs.

Estimation results show utilities' operating costs increasing in 2006 when the share of municipalities aligned to regions is larger than in 2002. When adding a variable for political alignment to central government in 2006, the estimated coefficient, although not statistically significant is negative which warrants further research.

The analysis was performed with data collected from the 2002 and 2006 elections so political variables are crafted and included in a stochastic cost frontier model with panel data for 47 water utilities.[1] A Random-effects GLS estimation checks the robustness of the results.

The rest of the study is organized as follows. Section two presents a review of the literature. Section three describes the political-administrative organization of Peru and its water sector. Section four presents the empirical analysis. Section five discusses results from estimation, and section six concludes and comments on further research.

2. Review of the literature

I will mention studies from two literature strands, fiscal decentralization from the public policy area and the effects of political alignment, in general political factors, on government processes from the political economy area.

The decentralization effects on public service provision have been extensively analyzed in the literature. Early findings from Oates (1972) show a decentralized scheme superior to a centralized one, assuming no spillovers, but with concerns about the proper functioning of local democracies. Oates (1999) measures the marginal rate of substitution between economic efficiency of local government and political participation. Besley and Coate (2003) present a study where the pros and cons for service provision of public goods under a centralized versus a decentralized scheme are analyzed.

Faguet and Sanchez (2014) study the effect of decentralization on the provision of health and education services in Colombia. The authors conclude that decentralization made a positive impact in the provision of these services. The awareness of local government officials to local service needs made the public expenditures to be more in agreement to these needs, producing an improvement of the services, which supports the assumption made in the analysis of the water sector in Peru.

The Herrera and Post (2014) study is the most relevant to the relate to the political aspect, supporting the analysis. The authors analyze the effects of decentralization and privatization reforms in the water sector of developing countries. These reforms aim at increasing citizen participation and insulating the sector from political intervention, respectively. When adopting these reforms in parallel the authors find that increasing citizen participation has made it difficult to shield utilities management from politics. In the case of Peru, the political connection is unavoidable given that the directors of the board are selected by the local political authorities. The authors argued that political influence affects the revenues available for maintenance and or investment and even affects service quality and coverage. The rationale is that less political intervention would allow service providers to adopt revenue and collection policies that would let them fund expenditures with a larger share of consumers' revenue, rather than being income dependent on government funding. Examples of these policies are better

[1] Cost data facilitated by the regulator SUNASS (Superintendencia Nacional de Servicios de Saneamiento); Electoral data from National Office of Electoral Process (ONPE) website last access 12/25/2024: https://www.onpe.gob.pe

control of water loss, clandestine connections and penalization of no service payment.

The literature showing studies where political alignment plays a role is not as rich as the one on decentralization. Here I mention a few analyses on various public sectors and countries showing political factors, or political alignment as important to various government processes and some related to the water sector. My objective is to browse on some of the analysis that I believe put this analysis in perspective.
I start with the Baerlocher and Schneider (2021) study on the effects of political alignment between the legislative branches and the central government on the time elapsed when transferring government resources such as grants. The authors show that when there is alignment between the legislators and the central government the transfer of resources happens nine months faster than in the case of unaligned legislators. This result evidences the impact of political alignment on government processes.

Callen et.al (2020) analyze the case of health services in Pakistan and find that in areas where incumbent politicians were voted by constituents, more resources are assigned, for example more doctors. However, this does not mean that the service improved. The authors argue that the increase in service is counteracted by lower quality of service neutralizing the political alignment effect.

Lara and Toro (2019) analyze the case of Chile and the political influence on the allocation of resources from the central government to the localities. In terms of political economy this is called tactical distribution. The findings indicate that the central government “value” aligned mayors and that central government places greater value on municipalities that have historically been under the control of its coalition.

Gonschorek et. al. (2018) is an ambitious study on Indonesia where the authors try to disentangle what originates the allocation of grants, the needs of the locality, political reelection or the political alignment of the central government with local leaders. The authors find the political aspect to be of more importance than the actual needs of the localities, especially in election year. They find that when reelection is not possible, the effect is not present and that the incumbent president finds grants to be a tool for reelection. Yet, the study does not show political alignment to be relevant on the results.

An early study by Curto-Grau et al. (2012) investigates the effect of politically alignment on the transfer of government funds to municipalities in Spain. The authors found that “a local government controlled by the same party as the one leading the regional government receives 83% more funds for earmarked capital transfers than in the case of similar unaligned municipalities” (Curto-Grau et al. p 4, 2012). Then again, Curto-Grau et al. (2018) investigates the effect of political alignment looking into Spanish data and the case of transfers of resources from regions to local governments. The findings are blunt, showing that political authorities aligned to the regional president obtain double the amount that opposition authorities receive. The effect vanishes when elections are competitive.

This study once again validates the political factor as of great importance when analyzing governmental resources and their allocation.

Brollo and Nannicini (2012) present a review of articles on the impact of political alignment on government transfers under a decentralized government scheme. The authors find an effect referred as “punishing political enemies”, meaning that the central government is less willing to provide resources to a region lead by a political opponent.

Sole-Olle’s (2013), investigates inter-regional allocation of investment in infrastructure and looking into whether these transfers obey tactical or programmatic motives. Among other results the author finds tactical politics matter when central and regional governments are aligned. Once again, showing the relevance of political alignment on the allocation of resources. Again, Sole-Olle and Sorribas-Navarro (2008) analyze the case of transfer of grants to municipalities in Spain. They find that municipalities politically aligned with upper-tier grantor governments receive 40% more than unaligned ones.

Mueller et. al. (2017) investigates what makes some governments spend more than others considering political science and public policy literature. The authors look into the effects of decentralization on public spending, finding that when political actors (and processes) are organized locally rather than centrally, increases central and decreases local spending.

Kauneckis and Anderson (2009) analyze Latin America cases of decentralization and provides a literature review on the impact of decentralization on municipal governments when managing natural resources. What is important of this study is the fact that the authors conclude that local and national institutions together should determine political incentives in decentralized governments, suggesting that political alignment across government tiers is important for positive decentralization results. The next section provides details on the water structure of the country and water providers.

3. Political-administrative structure of the country and the water sector

Political-Administrative structure

Peru is a unitary decentralized republic with three levels of government: central government, regional and local governments.[2] The organic law passed in November 2002 defining previous departments as regional governments defines the political-administrative structure of the country as comprised of 25 regions and the capital (Lima). The executive power is held by the president and referred as national government. Each region is ruled by a governor with political, economic, and administrative autonomy. The governor’s main duties are the

[2] Decentralization Law Nov 18 2002 (Ley de Bases de la decentralization, #27783 – Julio 17, 2002), last access 12/25/2024. http://www2.congreso.gob.pe/sicr/cendocbib/con4_uibd.nsf/8B3C23D0EB9643D605257FD400782856/$FILE/27783.pdf

designation of government officials, budget execution, and setting regional investment plans.[3]

Regions are subdivided into provinces which are comprised of districts. To simplify the analysis, provinces are the municipalities comprising the third level of government.[4] Municipal governments are ruled by the mayor and a council. Councils are comprised of elected officials and a mayor who holds executive power. Both the council officials and the mayor are elected by direct suffrage every three years. There are 180 provinces and 1,747 districts in the country. As a decentralized republic, the governor of each region coordinates with municipal authorities on the implementation and development of plans for allocation of resources.

The decentralization process of the water sector in Peru, transferring water service provision responsibilities from the central government (top tier) to municipalities, the lowest of three government tiers, appears to be connected to the political events happening in the country ever since the 1990s. For instance, Tamayo et al. (1999) discuss differences in the decentralization process during the government periods of President Alan Garcia, when the process started, and later, when Alberto Fujimori was the country's president. Herrera and Post (2014) present an extensive analysis of the decentralization reforms with reference to the water service sector. Vergara (2011) provides an excellent background on the decentralization reform of Peru from a perspective of political science Regional and municipal leaders have played a crucial role in the provision of public services since the early 1990s. These leaders have had interest in gaining popularity with their constituencies and taking responsibility over a public service is viewed as an obvious political win (in Tamayo et al. 1999). This crucial role is important when learning about the ownership structure and leadership of water service providers, explained in the next section.

Water sector structure

Water service is provided by utilities called EPS (Empresa Prestadora de Servicio). Each utility provides service to *one region*, and within a region, to one or more municipalities. One region may be served by *more than one utility*. Table 1 displays summary statistics for the distribution of utilities within the country structure.[5] For example consider the region *SanMartin*. This region is comprised of 10 municipalities, 9 of these 10 are served by 2 utilities. Each utility is identified in one region. Table 1 also shows the name of the ruling political party in each region in the 2002 and 2006 elections.

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[3] Organic Law 2002 (Ley Organica de Gobiernos Regionales #27867- Nov 18,2002), last access 12/25/2024. http://www2.congreso.gob.pe/sicr/cendocbib/con2_uibd.nsf/67DAE9FB43F0233205257853006501EC/$FILE/Ley_27867.pdf

[4] Districts are small units and reflect the same political and administrative functioning than the provinces. Political data available is on provinces.

[5] Non-regulated water (unofficial water) can be provided by non-piped water and by community-managed water services (see Calzada et al. 2017).

Table 1: Summary statistics for water service by region

Region	Municipalities	Municipalities of the region served by water utilities	Utilities providing service in the region	Political Party of the region 2002	Political Party of the Region 2006
Amazonas	7	3	3	APRA	Fuerza democratica
Ancash	20	7	2	APRA	M.I. regional Cuenta Conmigo
Apurimac	7	1	1	A. I. union por el Peru – F.A.	Frente Popular llapanchik
Arequipa	8	8	1	APRA	Arequipa, tradicion y futuro
Ayacucho	11	2	1	APRA	M.I. innovacion regional
Cajamarca	13	5	2	APRA	Fuerza social
Cusco	13	6	3	Frente I. moralizador	Union por el Peru
Huancavelica	7	2	1	M.I. de campesinos y profesionales	Proyecto I. de comuniOrganizadas
Huánuco	11	2	1	M.I. luchemos por huanuco	Frente Amplio Regional
Ica	5	5	4	APRA	P. Regional de integracion
Junín	9	7	3	Unidos por Junín - sierra y selva	C.R. descentralista - conredes
La Libertad	12	5	1	APRA	APRA
Lambayeque	3	3	1	A. I. union por el Peru – F.A.	P. M. H. Peruano
Lima	10	4	4	APRA	C.D.RLima
Loreto	7	3	1	Unipol	Fuerza loretana
Madre de Dios	3	1	1	M. nueva izquierda	M.I. obras siempre obras
Moquegua	3	2	2	P. Democratico somos peru	M.I. nuestro ilo-moquegua
Piura	8	5	1	C.R. por la descentralizacion	M. nueva izquierda
Puno	13	7	4	APRA	APRA
San Martin	10	9	2	M. por la A.R. Quechua y Aymara M.	Avanza pais - p. integration social
Tacna	4	2	1	APRA	Nueva Amazonia
Tumbes	3	3	1	APRA	Alianza por Tacna
Ucayali	4	1	1	APRA	M.I. regional Faena
Average	8.3	4	1.8		
St. Dev.	4.29	2.4	1.11		

Each utility is owned by the municipalities they serve. A stakeholder committee comprised of leaders from the served municipalities is responsible for selecting six (6) members to comprise the board of directors. Each member of the board has a one-year term with an opportunity of reelection for one more year. Two board members cannot represent the same municipality.

Because the ownership of the utilities comes from representatives of the served municipalities, the assumption in the analysis is that the political party from the municipalities carries over to the board of directors and to the utility. That is, we assume that the members of the board are partisan of the municipal leaders that have selected them. Therefore, from the perspective of this analysis, referring to the political party of the municipality is the same as referring to that of the utility that serves it.

4. Empirical Analysis

Definition of variables

This study assumes that managers minimize total operating costs by choosing the quantity of input factors at given market prices and by making optimal quantity adjustments during the period of analysis. Cost efficiency entails how well managers select input factors with given market prices. Total operating costs are comprised of administrative, sales, finance expenses, and depreciation.[6] Output is exogenously determined by regulation, implying that utilities must deliver all the water being produced. As general practice for this sector the output variable is volume of water produced (see Berg and Marques 2011). In Peru, water utilities are classified by size according to the number of connections: small, medium and large. [7]

The analysis is considered a long run cost analysis given 10 years of data, so input prices instead of quantities are included in the cost model. For price of capital, I use as a proxy a debt index annually reported by the utilities to the water regulator. Debt is used to finance long-term investment such as network expansion, in this sector representing capital. It is expected that as a network expands, debt grows as well. The variable *debt-index* is defined as total liability divided by net equity expressed as a percentage. Debt/equity ratios vary according to the industry in which a company operates. Capital-intensive industries, such as the water service, tend to have high debt/equity ratios, usually above 2. However, the average debt index for the water sector during the analyzed period is 1.29, suggesting that on average investment in network expansion in this sector is low. with a higher value (1.77) found for medium size utilities. Summary statistics for this variable are displayed in Table 2 showing the lower index values for large utilities, then small and finally medium utilities, indicating how networks are being expanded by each utility category.

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[6] It is assumed that all firms in the sample adopted the same accounting definitions and that depreciation value is based on a similar estimation procedure for the assets in place of each firm.

[7] Large utilities serve more than 40,000 connections. Small utilities serve less than 10,000 and medium size utilities serve between 10,000 and 40,000 water connections.

Table 2: Debt index statistics by size of the utility

Size	Avg	Std. Dev	Median	Min	Max
Large	0.94	1.658	0.14	0.01	10.14
Medium	1.77	2.058	0.90	0.08	9.85
Small	1.30	1.869	0.61	0.09	9.39
Overall	1.32	1.873	0.535	0.01	10.14

The price for labor and administrative expenses is entered as unit terms, both annual labor costs and annual administrative expenses are divided by volume of water billed. This is a linear transformation with no distortion of the true relationship of these prices to operating costs. Table 3 depicts summary statistics for inputs, output, and total operating cost.

Table 3: Summary Statistics for input variables, output and total cost

VARIABLE	Units	Avg	Std. Dev	Min	Max
Debt Index (P1)		1.32	1.88	0.01	10.14
Unit price of labor (P2)	Soles/worker/m3	0.46	0.17	0.07	1.19
Unit price of materials(P3)	Soles/materials/m3	0.52	0.23	0.14	1.45
Volumeofwater (Y)	Millions m3	116	209	11.9	705
Tot.Oper. Costs (TCost)	Soles (in millions)	11.05	16.81	0.147	111

The variables SHARE02 and SHARE06 are constructed to capture political alignment between municipalities and regions in election years 2002 and 2006. These variables measure the share of municipalities served that are led by the same political party leading the regional government, and represents political alignment between the lower and medium government tier. These variables take values from zero to 1. For example, consider a utility serving 10 municipalities in region A led by party Z. Five of these 10 municipalities are also led by party Z. This makes the variable SHARE for this utility to be equal to 0.50, or 50%.[8] The data shows that in 2006, forty seven percent of municipalities served are of the same party as the one of the regional political leaders, while in 2002 the alignment is only 32%.

In the case of political alignment between regions and central government in 2002 fifty percent of the regions were led by the political party APRA (Popular Revolutionary American Party) but this party was not the ruler of the central government. In 2006 the leader of APRA won presidential elections but only two regions were led by this party. A dummy variable taking value 1 in case the region

[8] Note that all members comprising the group of municipalities served can be of the same party, but the variable SHARE could be equal to zero because what the variable measures is not the political alignment within the group of municipalities, but between the municipalities and the regional leader.

was led by the political party APRA in 2006 is included in the model to check its relevance.

To capture environmental conditions not under the control of management two exogeneous variables are included in the model. I use the index constructed by Herrera and Francke (2007) to categorize the municipalities in Peru using a cluster analysis. The index includes *population size*, degree of *urbanization* and *poverty*. These three variables are exogenous to management and capture economic differences of the area where water is provided. Using this index, I define the variable PROV-CATEGORY equal to values one to four if the municipality where the utility is providing service is considered, rural (1), semi-rural (2), middle (3), and metropolitan area (4), respectively.[9] Higher values of this variable are associated to larger utilities serving more urbanized and populated locations.

Finally, a non-discretionary factor that impacts the utilities cost is the source of water, whether it is found underground or not. Surface water for example does not need pumping but needs a more intense water treatment to meet quality standards. The variable GROUNDWATER is included to capture the percentage of underground water utilized by each utility. The sign and magnitude of this variable coefficient when estimated will explain whether the source of water is cheaper or expensive for the water utilities in Peru. We turn now to the definition of the empirical model and estimation strategy.

Empirical model and estimation process

The model uses a Translog specification to provide flexibility and to allow scale economies to vary with level of output, this is because of the different sizes of the utilities. Another reason for using this specification is that the functional form does not set a priori restrictions on the substitution among factors of production that is relevant under possible budget restrictions in the case of the water sector of Peru. The economic model is specified in Equation (1) where utility and time subscripts are omitted for clarity.

$$\mathrm{TCost} = \alpha + \beta Y + \sum_i \gamma_i P_i + \frac{1}{2}\beta_{YY}(Y)^2 + \frac{1}{2}\sum_i \sum_j \gamma_{ij} P_i P_j + \sum_i \gamma_{Yi} Y P_i + \sum_m \omega Z_m + \varepsilon \qquad (1)$$

In Equation (1), TCost is the total annual operating costs as defined previously; Y is volume of water produced; P_i is the vector of input prices, with i and j varying from 1 to 3 since there are three input prices; Z_m is the vector of political and exogeneous variables; ε is the residual term, and α, the β's, γ's and $\dot{\omega}$'s are parameters to be estimated.

This is a cost function model; therefore, regularity conditions are tested before estimation (see Appendix A). Results from regularity tests modify the functional form in Equation (1) and the model becomes specified as in Equation (2) reflecting the fact that the input mix was found to be constant with the size of the utility, and that returns to scale vary with the production mix and input price-output terms are eliminated.

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9 The value was averaged in the case where the utility serves multiple cities within different categories.

$$TCost = \alpha + \beta Y + \sum_i \gamma_i P_i + \frac{1}{2}\beta_{YY} Y^2 + \frac{1}{2}\sum_i \sum_j \gamma_{ij} P_i P_j + \sum_m \omega Z_m + \varepsilon \quad (2)$$

Turning now to the specification of the econometric model, in economic theory, maximum output occurs when a firm employs the optimum mix of inputs (given their price) and enjoys the best possible configuration of non-controllable (exogenous) variables. Maximum output represents a frontier in a production framework. But for each firm, actual output could deviate from this frontier. Persistent deviations from this maximum output imply the presence of either erroneous choices of the discretionary mix of inputs, or a less than favorable configuration of exogenous environmental variables. Sometimes it is a combination of both. An example of an erroneous choice would be purchasing material at a higher than the market price, or/and the quantity purchased is more than what is needed.

This persistent deviation is referred in the literature as *inefficiency* and the concept is based on Farrell's (1957) pioneering work on firms' efficiency. The maximum output previously mentioned represents a minimum cost frontier with deviations represented by a disturbance term ε. In equation (2) this disturbance is comprised of two components: noise (***v***) and inefficiency (***u***). In a cost frontier model, cost efficiency is relative to the efficient (minimum) cost frontier which is comprised of cost points from best practice companies.[10]

A stochastic frontier model is selected over a non-stochastic (deterministic) frontier to allow for errors that generally come from model misspecification and noise not detected on a non-stochastic frontier. In addition, a deterministic frontier considers firm's deviations from the frontier as pure inefficiency which may result in biased estimates.[11]

Atkinson and Cornwell (1994) express the frontier concept as a general form specifying inefficiency (u) as measuring the potential of each firm to reduce costs holding output constant, as in Equation (2.1):

$$TCost(Y,P/u,Z) = \min[(P/u)(uX) \mid f(uX) = Y] => (1/u)TCost(Y,P,Z) \quad (2.1)$$

As previously defined, TCost is the total annual operating costs; Y is volume of water produced; P is the vector of input prices; Z is the vector of political and environmental variables, inefficiency is u. The last equality in Equation (2.1) follows from the fact that a cost function is linearly homogeneous in input prices. Applying natural logs to both sides in Equation (2.1) yields a general representation of the model to be estimated, shown in Equation (2.2).

$$\ln[(1/u)TCost(Y,P,Z)] = \ln(1/u) + \ln TCost(Y,P,Z) \Rightarrow \ln TCost(Y,P,Z) - \ln u \quad (2.2)$$

[10] Aigner et al. (1977) in parallel with Meeusen and Van den Broeck (1977) introduced the concept of estimating a frontier instead of an average (production or cost) function to evaluate firm's efficiency.

[11] Murillo-Zamorano (2004) provides a comprehensive frontier classification and explanation.

An idiosyncratic error term (***v***) is added to the model depicted in Equation (2.2). This error term is independent of the regressors and follows a normal distribution with zero mean.

Regarding the estimation process, instead of using a two-step estimation method to assess inefficiency, as in Sow and Razafimahefa (2015), I follow Kalb (2010) one-step process in their study of intergovernmental grants. The one-step process estimation procedure is based on Coelli et al. (1999). The authors indicate that when exogenous environmental variables are included in the functional form, they affect its shape with the residual after estimation representing a net measure of inefficiency. When environmental variables are not included, the residual is said to be a gross measure of inefficiency. There are numerous studies in the empirical literature relating to this gross measure of inefficiency. These studies are based on including environmental variables in a second step to explain the gross inefficiency value obtained in the first step.

Yet, Simar and Wilson (2007) discuss several drawbacks of the two-step approach. The main point made by the authors is that once environmental variables have been identified, they should be included in the functional form to avoid misspecification. Therefore, there is no need for a second stage. This explains the inclusion of the identified exogenous variables (Z) directly in the cost functional form in Equation (2.2).

5. Discussion of results

Estimation results are shown in Table 4. I estimated four models, two using the XTFRONTIER command in STATA which uses the Maximum Likelihood (ML) estimator and two for robustness using the GLS estimator with Random effects. A Hausman test favors the random effects rather than a fixed effects estimator.

Table 4: Estimation results for Model 1 and Model 2 on natural log of operating costs

Variable name	Model 1 LogL= 200.97177	Model 2 R^2 = 0.9801	Model 3 LogL=201.50399	Model 4 R^2= 0.9801
Prov-category	0.0946*** (0.0367)	0.0758* (0.0439)	0.0944*** (0.3430)	0.0738* (0.0440)
Groundwater	-0.0877 (0.0612)	-0.0744 (0.0631)	-0.8758 (0.5567)	-0.0719 (0.0641)
SHARE02	0.0810 (0.0900)	0.0668 (0.0535)	0.1262 (0.0868)	0.0898 (0.0549)
SHARE06	0.1444*** (0.0528)	0.1123** (0.0554)	0.1552*** (0.0467)	0.1175** (0.0562)
SHARE06 x APRA06			-0.2214 (0.3160)	-0.2305 (0.1409)
Water Volume	-0.5314** (0.2659)	-0.6141 (0.5027)	-0.5783** (0.2580)	-0.6862 (0.5290)
Water Volume^2	0.051*** (0.0088)	0.0534*** (0.0166)	0.0526*** (0.0085)	0.0559*** (0.0175)
Price Labor	0.5562*** (0.0414)	0.5729*** (0.0914)	0.5507*** (0.0404)	0.5734*** (0.09112)

Variable name	Model 1 LogL= 200.97177	Model 2 R^2 = 0.9801	Model 3 LogL=201.50399	Model 4 R^2= 0.9801
Price Labor^2	0.2302*** (0.0319)	0.2413*** (0.0808)	0.2269*** (0.0299)	0.2413*** (0.0808)
Debtindex	-0.0051 (0.0096)	-0.0058 (0.0106)	-0.0048 (0.0096)	-0.0064 (0.0107)
Debt index^2	0.0088** (0.0034)	0.0082** (0.0043)	0.0087** (0.0034)	0.0081* (0.0043)
Labor x Debt	-0.0369** (0.0184)	-0.0396* (0.0230)	-0.0360** (0.0179)	-0.0398* (0.0230)
Constant	11.7351*** (1.878)	12.7354*** (3.7614)	12.0763*** (1.9119)	13.2427*** (3.9376)
	/mu=0.2028 (0.2242)	R^2Within=0.7453; R^2Between=0.9888	/mu=0.1508 (0.2352)	R^2Within= 0.7458; R^2Between=0.9888

Statistical Significance levels: *(90%); ** (95%); *** (99%). Standard errors in parenthesis.

To consider the possibility of inefficiency changing over time I included the time invariant option in the XTFRONTIER STATA command. The data comprises years 2002 to 2010 and there are 423 observations.[12]

The likelihood function for the frontier estimator of MODEL 1 and 3 is expressed in terms of the variance parameters, $\boldsymbol{\sigma}^2 = \boldsymbol{\sigma}_V^2 + \boldsymbol{\sigma}_u^2$ and gamma, $\boldsymbol{\gamma} = \boldsymbol{\sigma}_u^2 / \boldsymbol{\sigma}^2$. Gamma equals 0.56 for Model 1 and 0.61 for Model 3 suggesting a slightly better functional specification on Model 1. The Gamma value indicates that about 61% of the disturbance term is explained by inefficiency, leaving 39% to noise indicating a good model specification.

In all four models, the coefficient for SHARE06 is positive and statistically significant with higher than 95% confidence. This result indicates that Political alignment in the two lower consecutive tiers affect utilities by increasing their operating costs. This result may be explained by the fact that in 2006 a larger share of municipalities was politically aligned to the regional governments when comparing to year 2002.

This result suggests the possibility of regional governments having interference on the decision making of the utilities' board, affecting the utilities' cost behavior in some negative way. For example, costs may have increased because network was extended to political friendly municipalities without a proper support plan, or labor was hired when no needed.

The interacted term for SHARE06 and APRA06 was included in models 3 and 4 to inquire about the possible effect of political alignment of lower levels to central government. The coefficient is not statically significant but is negative. This interaction of the variables for year 2006 represents alignment of all three government layers in Peru.

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[12] Lima's water utility, Sedapal, is not included in the analysis. The volume of water produced and the fact that it is under the control of central government make this EPS not suitable to be included in the analysis. EPS Pasco and EMPSSAPAL S.A are dropped from estimation given that some of the variables used in the model had missing values.

Regarding the environmental variables, the coefficient for the province-category index is positive and statistically significant in all models. Overall it indicates that as this index increases by one, from a rural to a more urbanized and populated location costs increase which is expected and interpreted as provision increasing to serve more urbanized areas.

The coefficient for water volume is only statistically significant on the squared terms in all models and overall, it shows the presence of economies of scale in the sector.

The statistical significance for the labor elasticity is 0.01 in all models. The coefficients are larger in magnitude compared to the one for the debt variable suggesting that utilities are more resilient to wage increases compared to possible increases in debt. Note that coefficients for output and price of inputs may be somewhat inflated due to the perverse collinearity effect of the squared terms of the Translog functional form.
The coefficient for the interacted input prices is negative and statistically significant in all models indicating that for the same level of output, labor and debt are complements, extending the network is accompanied by a labor increase. The square terms for all input prices are positive and statistically significant. This means that an increase in these prices impacts costs at an increasing rate.

Finally, the coefficient for the output variable is about the same magnitude as the coefficient for the price of labor. It suggests that the expansion (or growth) of service provision in a particular area implies a proportional increase in labor.

6. Concluding remarks

This study analyzes the impact of political alignment in the delivery of public water service under the decentralized government structure in Peru. The main result is that the political alignment across government tiers in 2006 show utilities' operating costs higher. That is, costs are higher when the regional government and the municipal governments under it are controlled by the same political party as it was the case in 2006. This suggests that cost inefficiencies may cancel out improvements from decentralization. Without doubt, this needs to be further investigated. Studies on other countries and other public sectors would be helpful to better understand this possible effect.

I assumed in the analysis that the larger the number of municipalities politically aligned to the regional leader, the higher would be their bargaining power when asking for resources to the regional leader. At the same time, this political alignment could give the regional government higher leverage allowing them to influence utilities' operational decisions and directly affecting costs. I did not look into these two possible causes separately in the analysis which grants another avenue of research.

When inquiring about the possible effect of political alignment of lower levels to central government the model estimation produces a coefficient to the political variable that is not statically significant but shows a negative sign that warrants further investigation. This interaction of the variables for year 2006 represents alignment of all three government layers in Peru. The fact that the coefficient is negative suggests that when all three government tiers are aligned, operational costs decreases indicating higher cost efficiency as opposed to the cost increase outcome when only the two lower tiers are politically aligned. This is a puzzling result not only because of the sign change but also considering that only two regions had the same political party as the central government in 2006, the APRA party.

Given the influence of political alignment in this sector and country, it is hard to offer suggestions for the regulator but it definitely improves the information about such an important sector. In conclusion, this study provides information relevant to policy makers and regulatory authorities involved with the water sector, and also relevant to stakeholders related to the provision of other public services. An interesting follow-up research might be the consideration of additional election years, and other public sectors in Peru such as electricity distribution.

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Appendix A. Regularity conditions of the cost function

The model is stated as a cost function and regularity conditions need to be tested before proceeding to estimation. A well-behaved cost function is concave in input prices and non-decreasing in output. A necessary and sufficient condition for concavity in prices is that the matrix of second order partial derivatives of the cost function with respect to prices is negative semi-definite, assuming the cost function twice continuously differentiable. This is accomplished by imposing symmetry on the parameters of the interacted input prices ($\gamma_{ij} = \gamma_{ji}$ for all i ≠ j). Additionally, the price shares need to be positive over the price domain, in this case at mean values (Diewert and Wales, 1987).

A cost function is homogeneous of degree one in prices if cost increases proportionally with prices for a fixed level of output. This restriction is specified in Equation (1.1) and imposed in the model by normalizing the price of inputs and total cost by one of the input prices (in this model by price of materials).

$$\sum_i \alpha_i = 1; \sum_i \gamma_{Yi} = 0; \sum_i \gamma_{ij} = \sum_j \gamma_{ij} = \sum_i \sum_j \gamma_{ij=0} \tag{1.1}$$

Homotheticity and homogeneity in output are properties that describe the behavior of the production process and closely tied to the cost function. Following Diewert (1974) and Christensen and Green (1976), these properties can be tested after imposing the restrictions specified in Equations (1.2) and (1.3) respectively to the model.

Homotheticity requires: $\gamma_{Yi} = 0$ (1.2)

Homogeneity in outputs requires: $\gamma_{Yi} = 0; \quad \gamma_{YY} = 0$ (1.3)

A likelihood ratio test at 0.01 level of statistical significance could not reject the null hypothesis of homotheticity. The production function being homothetic implies that the input mix is constant with scale. Therefore, interacted output-input terms are dropped from MODEL 1, that is, they are not included at estimation time. The homogeneity hypothesis is rejected after a likelihood ratio test at a 0.01 level of statistical significance. This implies that returns to scale vary with the production mix and requires that the output squared term stays in the model at estimation time. After the regularity conditions results are imposed, the model to be estimated is depicted in Equation (1.4).

$$\mathrm{TCost} = \alpha + \beta Y + \sum_i \gamma_i P_i + \frac{1}{2}\beta_{YY} Y^2 + \frac{1}{2}\sum_i \sum_j \gamma_{ij} P_i P_j + \sum_m \omega Z_m + \varepsilon$$