MARCH 2020

DISCUSSION PAPER SERIES NO. 2020-06

Efficiency of Local Governments in Health Service Delivery: A Stochastic Frontier Analysis

Janet S. Cuenca

CONTACT US:

RESEARCH INFORMATION DEPARTMENT
Philippine Institute for Development Studies

18th Floor, Three Cyberpod Centris - North Tower
EDSA corner Quezon Avenue, Quezon City, Philippines

publications@mail.pids.gov.ph
(+632) 8877-4000

https://www.pids.gov.ph

Efficiency of Local Governments in Health Service Delivery: A Stochastic Frontier Analysis

Janet S. Cuenca

PHILIPPINE INSTITUTE FOR DEVELOPMENT STUDIES

March 2020

(Updated May 2020)

Abstract

The study analyzes the efficiency implications of fiscal decentralization using stochastic frontier analysis (SFA). It uses LGU health expenditure (in per capita real terms) as input. The output variables of interest include access to safe water and sanitation, health facility-based delivery, and access to hospital inpatient services. It also uses LGU income and its major components (i.e., own-source revenue and IRA, in per capita real terms) as covariates; as well as the health expenditure decentralization ratio to account for fiscal autonomy on the expenditure side and two measures of fiscal decentralization to account for financial/fiscal autonomy of the local government units (LGUs) on the income side (i.e., the ratio of LGU own-source revenue to LGU expenditures and ratio of LGU own-source revenue to LGU income) as factors affecting efficiency. The findings of SFA lend empirical evidences to what the literature says about the health devolution experience in the country. Issues on mismatch between local government fiscal capacity and devolved functions, fragmentation of health system, existence of two-track delivery system, and unclear expenditure assignments, among others inevitably create inefficiency. These issues should be addressed to fully reap the potential benefits (e.g., efficiency gains) from fiscal decentralization, particularly health devolution.

Keywords: efficiency, health devolution, fiscal decentralization, stochastic frontier analysis

Table of Contents

List of Tables

Efficiency of local governments in health service delivery: A stochastic frontier analysis[*]

Janet S. Cuenca[**]

1. Introduction

Efficiency[1] is the major underlying argument for fiscal decentralization. Decentralization increases allocative efficiency (i.e., through better matching of public services to local preferences) and productive efficiency (i.e., through increased accountability of local governments units or LGUs to citizens, fewer levels of bureaucracy, and better knowledge of local costs), both of which are essential ingredient for improved governance and public service delivery (Kahkonen and Lanyi 2001). The Oates' Decentralization Theorem[2] that was first introduced in Oates (1972, p.35) formalizes the basic efficiency argument for decentralized provision of public goods (Oates 2006).

Efficiency gains in fiscal decentralization are expected assuming that LGUs have the capability to better identify and fulfill the needs of the households owing to their proximity to them, and fiscal capacity to mobilize and use local resources in financing goods and services with purely local impacts (Loehr and Manasan 1999). Governments closest to the citizens have the capability of adjusting budgets/costs in such a way that the provision of public services is responsive to local preferences (Ebel and Yilmaz 2004). In this light, the efficiency gains in fiscal decentralization are in part determined by the LGUs' capability to improve resource allocation.

Efficiency and equity are two critical objectives for the performance of the health system (WB 1994). By efficiency, the WB report means that system operates efficiently such that the health outputs (i.e., health services) are produced at the least cost (i.e., productive efficiency) and that the output level is responsive to both national and local priorities for health (i.e., allocative efficiency). The argument that decentralization promotes allocative and productive efficiency is grounded on the assumption that "the devolution of functions occurs within an institutional arrangement that provides political, administrative, and financial authority to local governments, along with effective channels of local accountability and central oversight (Kahkonen and Lanyi, 2001, p.1)."

---

[*] This paper was lifted from Chapter 4 of the author's PhD Dissertation titled "Fiscal Decentralization and Health Service Delivery: The Philippine Case." The usual disclaimer applies.

[**] Supervising Research Specialist at the Philippine Institute for Development Studies and PhD Candidate at the Lee Kuan Yew School of Public Policy, National University of Singapore. The author acknowledges the valuable research assistance of Ms. Lucita M. Melendez.

[1] The type of efficiency being examined in this study refers to the fundamental idea of the use of the fewest inputs such as resources to produce the most outputs or services as defined in Bogetoft and Otto (2011). In this sense, efficiency is technical (or productive), which pertains to the "ability to avoid waste, either by producing as much output as technology and input usage allow or by using as little input as required by technology and output production." It should be differentiated from productivity, which is the ratio of a unit's output to its input (Fried, Lovell, and Schmidt 2008, p. 26).

[2] "For a public good – the consumption of which is defined over geographical subsets of the total population, and for which the costs of providing each level of output of the good in each jurisdiction are the same for the central or for the respective local government – it will always be more efficient (or at least as efficient) for local governments to provide the Pareto-efficient levels of output for their respective jurisdictions than for the central government to provide any specified and uniform level of output across all jurisdictions." Also, "each public service should be provided by the jurisdiction having control over the minimum geographic area that would internalize the benefits and costs of such provision."

Health devolution in the Philippines was primarily aimed at achieving efficiency and effectiveness of health service delivery through reallocation of decision-making capability and resources to the LGUs (Grundy et al. 2003; Galvez-Tan et al. 2010). With health devolution in place since April 1993, it is an opportune time to assess its efficiency implications by examining the effect of fiscal decentralization on the efficiency of local government health spending in the Philippines. Such analysis is deemed critical to determine whether health devolution engendered efficiency, particularly in local government health spending and in turn, understand why fiscal decentralization failed/succeeded in improving health service delivery at the local level. Moreover, it is useful in shedding some light on the factors affecting health spending efficiency.

The question: "Has health devolution in the Philippines resulted in efficiency?" has not been adequately addressed in the literature. In this light, the study aims to examine the efficiency implications of fiscal decentralization on health service delivery using quantitative approach, particularly Stochastic Frontier Analysis (SFA). In particular, it examines the cost efficiency of LGUs (i.e., provinces, municipalities, and cities, excluding highly urbanized cities and independent component cities) consolidated at the province level in terms of delivering health services such as hospital inpatient services, health facility-based delivery, and access to safe water and sanitation for the period 2001-2013, except 2005 due to data unavailability. The econometric model used in the study takes into account covariates which influence health expenditure, namely, the local governments' total income in real per capita terms, or its components namely, internal revenue allotment (IRA) and own-source revenue, both expressed in real per capita terms.

The study also establishes empirically the effect of fiscal decentralization as measured by financial autonomy ratio in terms of either (i) the ratio of own-source revenue to LGU expenditure, or (ii) the ratio of own-source revenue to total LGU revenue; and health expenditure decentralization ratio (i.e., the ratio of LGU health spending to general government health spending, where general government is national government, i.e., DOH and LGU combined) on efficiency in the conduct of SFA. In this sense, it attempts to employ SFA in examining the efficiency of Philippine LGUs that are consolidated at the province level, with focus on the effect of fiscal decentralization on efficiency of LGU health spending.

The study is organized as follows. Section 4.2 reviews the literature on fiscal decentralization and efficiency. Section 4.3 presents the methodology and data. Section 4.4 analyzes the results. The study ends with the concluding remarks (policy implications) in Section 4.5.

2. Review of Literature

Historical review of Philippine devolution points to some negative effects of decentralization (Grundy et al. 2003). Various issues such as fragmentation of health services and unclear expenditure assignments[3] arose after health devolution, thus limiting the potential benefits (e.g., efficiency gains) from fiscal decentralization. Health devolution caused a breakdown in the District Health System that was established during the pre-devolution phase, which resulted

[3] Due to the existence of a two-track delivery system as pointed out in Gonzales (1996), Manasan (2005), and WB (2010); Unambiguous and clear assignment of functions, and appropriate assignment of expenditure responsibilities across levels of government are widely identified in the literature on fiscal decentralization as enhancing efficiency gains (Manasan 2005).

in fragmented health system (DOH 2005; World Bank 2011). Such fragmentation prevented efficient utilization of resources (DOH 1999).

In a highly fragmented health system, there has been lack of coordination among health facilities, thus making it difficult to collect and manage health information (Dorotan and Mogyorosy 2004; Solon and Herrin 2017). Severe fragmentation in sub-national government causes inefficiency in basic service delivery (World Bank 2010). Persistent inefficiency in service delivery is due to weak patient referral and gatekeeping (Romualdez et al. 2011). Low efficiency in government spending is associated with the inability to optimize the use of available resources. More specifically, low efficiency in public health spending is attributed to highly fragmented health financing (Ecorys 2015). Subsequently, implementing health policies and reforms has been challenged by the decentralized system (DOH 1999b, Romualdez et al. 2011; Solon and Herrin 2017).

The literature on efficiency of LGUs in health service delivery in the Philippine context is scant. Only two published journal articles (i.e., Lavado and Cabanda 2009 and Lavado et al. 2010) look at the efficiency of public health units, particularly provinces in delivering health services.[4] Lavado and Cabanda (2009) examine the efficiency of provinces in using limited public resources for health (i.e., 1 percent of total budget) and for education (i.e., 3% of total budget) by conducting the data envelopment analysis (DEA), free disposal hull, and Malmquist-DEA using expenditures for social services as inputs and life expectancy as health outputs as well as primary and secondary enrollment rates as education outputs. The least efficient provinces are identified as those with higher level of inequality (i.e., measured by the Gini coefficient) and those that are highly dependent on grants.

Lavado, Lagrada, and Gozun (2010) assess the efficiency of provinces in health service delivery (i.e., in terms of health programs such maternal health care, child health care, and environmental sanitation) by employing DEA. The inputs used include health unit budget per capita, number of doctors and midwives per 100,000 population, and the percentage of rural health units accredited by the Philippine Health Insurance Corporation. The programs' outcomes include the prevalence of contraceptive use and percentage of fully immunized children, for maternal and child health care programs; and the percentage of people who have access to potable water and sanitary toilets, for environmental sanitation. The study identifies different sets of efficient provinces depending on the input used (i.e., health unit budget per capita to analyze expenditure efficiency and the rest of the inputs to examine technical efficiency).

The limited budget for health and education, and the vast majority of the population served by public health units motivated Lavado and Cabanda (2009) and Lavado, Lagrada, and Gozun (2010), respectively, to assess the efficiency of provinces in service delivery. The latter recognizes that devolution transferred the responsibility of providing health services from the national government to the LGUs. Fiscal transfers (i.e., measured in terms of fiscal grants per capita and fiscal grants as percent of total financial resources of the province) is one of the

[4] Unpublished versions of these cited journal articles are also available in the literature; Other efficiency analysis done in the Philippine context concerns microfinance institutions/ cooperative rural banks (e.g., Lamberte and Desrochers 2002, Alinsunurin 2014); electric cooperatives (e.g., Lavado 2004, Lavado and Barrios 2008, Valderrama and Bautista 2009); higher educational institutions/state universities and colleges (e.g., Castano and Cabanda 2007, Ampit and Tan-Cruz 2007, Cuenca 2011/Cuenca 2013); manufacturing firms (e.g., Gayosa and Cabanda 2014); water districts (e.g., Aberilla and Yee 2016), municipal fisherfolk (e.g., Digal et al. 2017); and local government units (e.g., Baldemor 2018).

environmental variables that were identified to explain differences in efficiency scores among provinces, along with real per capita income, inequality, family expenditure on health and education, and environmental sanitation.

The literature review focuses on some studies that empirically link fiscal decentralization and efficiency (Table 1). The studies provide insights on the effect of fiscal decentralization on efficiency. Findings of majority of these studies indicate that fiscal decentralization has positive effect on efficiency (e.g., Barankay and Lockwood 2007;[5] Chen and Zhang 2009; De Nicola, Gitto, Mancuso, and Valdmanis 2013; Adam, Delis, and Kammas 2014; Otsuka, Goto, and Sueyoshi 2014; Liu, Hu, Tang 2016; and Ghani, Grewal, Ahmed, and Noor 2017).

Other empirical evidences (e.g., Boetti, Piacenza, and Turati 2012; lo Storto 2013; Šťastná & Gregor 2015; Tu, Lin, and Zhang 2018; and Martinez, Arzoz, and Apezteguía 2018) suggest otherwise. In contrast, findings of Balaguer-Coll, Prior, and Tortosa-Ausina (2010); Sow and Razafimahefa (2015); and Zhu and Peyrache (2017) suggest mixed results. The impact of fiscal decentralization on efficiency depends on certain conditions such as political and institutional environments and the degree of expenditure decentralization. Without these conditions, fiscal decentralization can have negative effect on the efficiency of public sector efficiency (Sow and Razafimahefa 2015).

Data envelopment analysis (DEA) and stochastic frontier analysis (SFA) are the two most common approaches or standard techniques in conducting efficiency analysis (Hussey et al. 2009; Boetti, Piacenza, and Turati 2012; Table 1). They form part of a type of methodologies for measuring efficiency called "frontier analysis,"[6] which compares a unit's (e.g., local governments, banks, hospitals, etc.) use of actual inputs and outputs to efficient combination of multiple inputs and/or outputs (Hussey et al. 2009). Frontier analysis is also known as benchmarking, which "is the systematic comparison of the performance of one firm against other firms (Bogetoft and Otto 2011, p.1)."

More specifically, efficiency is measured by comparing a unit's observed/actual output (or input) to the maximum potential output obtainable from the input, i.e., optimal output (or minimum potential input required to produce the output, i.e., optimal input). The optimum (i.e., optimal output/input) is defined in terms of production possibilities and thus, efficiency is technical. It is located on the relevant frontier. In general, efficiency scores of units are measured in terms of their distance from an estimated production frontier (Simar 1992; Simar and Wilson 2000; Rosko and Mutter 2008). However, the "true" potential/frontier is unknown and thus, approximation (i.e., often dubbed as "best-practice" frontier) is required (Fried, Lovell, and Schmidt 2008).

[5] Albeit it focuses on education
[6] Frontier methodologies involve comparison of all observations with the best practices (Da Cruz and Marques 2014)

Table 1. Studies on decentralization and efficiency

Author(s)	Method	Sample	Inputs (I) and Outputs (O)	Main Findings
Australia				
Drew, Kortt, and Dollery (2015)	DEA and Tobit analysis	151 municipalities of New South Wales in 2009-2011	O: Number of businesses in the municipality, number of households in the municipality, total length of roads (in kms) maintained by the local government, and population I: Number of staff in full-time equivalent units, total staffing cost, material and other expenses, nd borrowing costs Explanatory variables for efficiency: Population, population density, percentage of population over 65 and under 65, percentage of Aboriginal and Torres Strait Islander population, annual unemployment rate, average annual wage, total liabilities, total infrastructure value, grant funding, depreciation in dollars, sealed roads in km, and unsealed roads in km	Grants has positive impact on efficiency.
Brazil				
Sampaio de Sousa and Stosic (2005)	DEA	4,796 Brazilian municipalities	O: Total resident population, literate population, enrollment per school, student attendance per school, students who get promoted to the next grade per school, students in the appropriate grade per school, households with access to safe water, households with access to sewage system, households with access to garbage collection I: Current spending, number of teachers, rate of infant mortality, and hospital and health services Explanatory variables for efficiency: Spatial and localization effects, socio-economic impacts (e.g., income level and poverty proxy), royalty revenues on oil and water, economic of scale indicators (e.g., population density and urbanization rate), political impacts (e.g., mayor's political party), management variables (e.g., proxy for a good fiscal administration such as the degree to which the real estate is up-to-date and participation in intermunicipal consortia)	More power awarded to municipal councils, the better the effectiveness in resource utilization as measured by efficiency indices

Table 1. Studies on decentralization and efficiency (cont.)

Author(s)	Method	Sample	Inputs (I) and Outputs (O)	Main Findings
China				
Tu, Lin, and Zhang (2018)	DEA, Tobit analysis	31 provinces in 1998 to 2015	O: Number of kindergartens; number of classes in kindergartens; number of preschool children in kindergarten; number of full-time teachers served for per 10,000 children; number of full-time teachers with bachelor degree; average school dormitory area per student I: Public expenditure on preschool education personnel; public funds expenditure in preschool education; capital construction expenditure in preschool education Control variables: Population density; GDP per capita; urbanization level; level of education; change of preschool education policy after 2010; fiscal decentralization	After the control of population, social and econom factors, the influence of fiscal decentralization upc the efficiencies on preschool education public spending is negative, the efficiencies on preschoo education spending of local government has been greatly improved by preschool education policy in China.
Chen and Zhang (2009)	DEA	27 provinces in the period 1978-2005	O: Comprehensive output index based on: Education indicator - the ratio of the number of teachers and staff in regular higher education, specialized colleges, secondary schools and primary schools to the total population of each province; Sanitation indicator - the per capita number of beds and doctors in healthcare institutions in each province; Infrastructure construction indicator - each province's ratio of irrigated area to total area, electricity consumption per capita in rural areas, the length of transportation routes (including railways and highways), per capita, and the business volume of postal and telecommunication services per capita I: budgetary fiscal expenditure per capita (in yuan per capita) Control variables: Population density; real GDP per capita; ratio of number of students in higher education and specialized colleges, secondary, and primary education to the local population; degree of foreign trade dependency; foreign direct investments; per capita budgetary fiscal revenue for each province; per capita extra-budgetary revenue; government size; government admin. fees per capita; per capita expenditure on capital construction	With the introduction of the TSS reform in 1994, there was a significant overall improvement in the expenditure efficiency of local governments. The fiscal behavior of local governments also has a gre influence on their expenditure efficiency.

Table 1. Studies on decentralization and efficiency (cont.)

Liu, Hu, Tang (2016)	Empirical analysis of Spatial Durbin Model; Use of Superefficiency Slack Based Measure, which is the approach of computational efficiency based on slack variables	281 prefecture-level cities in 2003-2012	O; Desirable output of deposit and loan; undesirable output of income gap between urban and rural I: Labor input of financial industry; capital input of financial industry; information technology level Control variables: Regional economic development, urbanization, industrial structure, information technology development, fixed asset investment, level of internal opening,	The estimated results indicate that there exist significant spatial spillover effects among regional financial efficiency with the features of time inertia and spatial dependence.The positive promoting effect of fiscal decentralization on financial efficiency in local region depends on the symmetry between fiscal expenditure decentralization and revenue decentralization. There exists inconsistency in the spatial effects of fiscal expenditure decentralization and revenue decentralization on financial efficiency in neighboring regions. The negative effect of fiscal revenue decentralization on financial efficiency in neighboring regions is more significant than that of fiscal expenditure decentralization.
Italy				
Boetti, Piacenza, and Turati	SFA, DEA	262 municipalities in Turin, Italy	O: Population (number of served inhabitants); total amount of waste collected; total number of pupils and old people; and total length of municipal roads I: Costs as accounted in the municipal budget or total current expenditure for the following services: General administration, waste management, education, elderly care, road maintenance and local mobility Control variables: Fiscal autonomy, which is the ratio of municipal own taxes to total current revenues; local tax revenues per capita; high taxes; fee and charges per capita; high extra taxes; grants per capita; potential incentives to higher efficiency (i.e., Domestic Stability Pact); and municipal income as a control for the (demand of) quality of the public output; distance of the municipality from Turin; population density; political indicators; and waste management indicators	The negative impact on expenditure stemming from a greater tax autonomy of municipalities targets inefficient spending, i.e., the waste of resources with respect to the amount required to satisfy citizens' needs.

Table 1. Studies on decentralization and efficiency (cont.)

Author(s)	Method	Sample	Inputs (I) and Outputs (O)	Main Findings
De Nicola, Gitto, Mancuso, and Valdmanis (2013)	Bootstrapped DEA	Balanced panel of 101 provinces in 2004-2005	O: Number of total patients; case mix I: Physicians, beds, nurses Control variables: Organizational models, reimbursement systems, total mobility, interregional mobility, province population, South, year	A degree of decentralization from the regional governments to local health units may indeed yield substantial gains for the healthcare system.
lo Storto (2013)	DEA	103 major Italian municipalities in 2011	O: Urban infrastructure development; urban ecosystem quality; nursery schools, municipality area extension, and resident population I: Annual expenditures relative to urban waste management; public transportation; general consumptions (i.e., phone, gas, electricity,water); leases and rentals; cleaning services; cars and property maintenance; communications and representation; miscellaneous (stationery, consumables, and supplies), advise and consulting services	There exist scale inefficiencies in a number of municipalities that need an indepth investiagation.
Japan				
Otsuka, Goto, and Sueyoshi (2014)	SFA	47 prefectures, every five years between 1980 and 2010	O: Population; area size I: Total expenditure or administrative expenses Social-environmental factors: Densely inhabited district population ratio, daytime population ratio, population ratio of ages under 15, population ratio of ages 65 or older, inhabitable land area ratio Explanatory variables for efficiency: Population size and fiscal transfer, which is hypothesized to reduce cost-efficiency of local governments	Looking at total expenditure, there is a statistically significant positive effect of fiscal transfer on the cost-efficiency of local governments. It means that fiscal transfers exacerbate the cost-efficiency of local governments.
Malaysia				
Ghani, Grewal, Ahmed, and Noor (2017)	DEA, Tobit analysis	13 states in 1990-2009	O: State revenue; private domestic investment I: Public expenditure	Tobit panel data analysis showed evidence that fiscal decentralization had positive and significant influence on state efficiency level, but that further efficiency gains could have been realized with greater decentralization.

Table 1. Studies on decentralization and efficiency (cont.)

Author(s)	Method	Sample	Inputs (I) and Outputs (O)	Main Findings
Portugal				
Da Cruz and Marques (2014)	DEA, Tobit analysis, OLS, double-bootstrap models; slacks-based measure of efficiency and SFA	308 Portuguese municipalities in 2009	O: Population, extension of municipal roads, urban waste collected, drinking water supplied, wastewater treated, and infrastructures I: Number of staff, capital expenditures, and other operationall expenditures Explanatory variables for efficiency: natural determinants (e.g., littoral zone, tourism, island, topography); citizen-related determinants (e.g., crime rate, illiteracy, mandatory education, voter turnout, aging index, concentration, population density, automotive fuel consumed, GDP per capita, new vehicles sold, purchasing power); institutional determinants (e.g., corporatization, ideology, new government, average payment period, financial independence); legacy determinants (e.g., area, density of parishes, number of parishes, public housing, net debt)	Financial independence (i.e., share of self-generated revenue on total revenue) seems to affect local governments' performance positively; yet, the double-bootstrap model does not support this.
Spain				
Balaguer-Coll, Prior, and Tortosa-Ausina (2010)	FDH	Spanish municipalities with a population over 1,000 inhabitants for the years 1995 and 2000 (i.e., 1,221 municipalities for each sample year)	O: Outputs based on services that municipalities provide (e.g., public street lighting, waste collection, and street cleaning, among others) I: Budgetary data (e.g, wages and salaries, expenditure on goods and services, and capital expenditures, among others)	The study cannot provide a clear-cut answer as to whether enhanced decentralization, or enhanced centralization is "good" or "bad" in terms of efficiency.
Balaguer-Coll, Prior, and Tortosa-Ausina (2007)	DEA, FDH Nonparametric smoothing techniques	Local governments/ municipalities in Comunitat Valenciana/ Valencian region (Spain) in 1995	O: Outputs based on services that municipalities provide (e.g., public street lighting, waste collection, and street cleaning, among others) I: Budgetary data (e.g, wages and salaries, expenditure on goods and services, and capital expenditures, among others) Explanatory variables for efficiency: tax revenue, grants, or financial liabilities; political variable, i.e., the percentage of votes attained by the governing party in each municipality; financial deficit, self-generated revenues	Efficiency decreases with tax revenues, self-generated revenues, and deficit. Grants offer a clearly decreasing pattern. Grants (i.e., transfers from higher levels of government) has negative impact on efficiency, which is consistent with other studies that suggest that grants may not only encourage local service provision, but also stimulate inefficiency.

Table 1. Studies on decentralization and efficiency (cont.)

Author(s)	Method	Sample	Inputs (I) and Outputs (O)	Main Findings
Switzerland				
Barankay and Lockwood (2007)	Econometric estimation of the relationship between decentralization and efficiency of public good provision in the educational sector	26 Swiss cantons over the period 1982-2000	O: Education output (maturite rate, i.e., the number of students who obtain the university entrance level qualification deflated by the size of the 19-year-old population) I: Expenditure per pupil; class size in upper secondary school; non-native speakers; business cycle Control variables: decentralization (i.e., average of past 12 years; average of past 5 years; average of 6 to 12 years lagged)	The changes in decentralization experienced in the last five years of education matter in education output.
OECD countries				
Martinez, Arzoz, and Apezteguía (2018)	DEA	23 OECD countries over the period 1992-2009	O: GDP in constant US dollars I: Number of employed; physical capital stock in constant US dollars; average number of years schooling of the total population multiplied by the number of employed Control variables: Fiscal decentralization as measured by the subnational share of total publicexpenditure and the subnational share of total government tax revenue	Fiscal decentralization of expenditure and revenue has a negative impact on technical efficiency, that is, countries that are more decentralized show lower levels of technical efficiency.
Adam, Delis, and Kammas (2014)	DEA, SFA	21 OECD countries between 1970 and 2000	O: Years of schooling multiplied by the educational quality indicator called "cognitive" multiplied by the ratio of public to total spending on education; and Inverse of infant mortality rate multiplied by the ratio of public to total spending on health I: Public education spending as a share of GDP; and public spending on health as a share of GDP Control variables: log of real GDP per capita; log of total population; population density; share of urban population to total population; ethno-linguistic fractionalization; structure of political system; structure of the elected government; and regulatory government	Fiscal decentralization has positive effect on public sector efficiency.

Table 1. Studies on decentralization and efficiency (cont.)

Author(s)	Method	Sample	Inputs (I) and Outputs (O)	Main Findings
Cross-country analysis				
Sow and Razafimahefa (2015)	Stochastic Frontier Method	Unbalanced panel of 64 countries during 1990-2012	O: Infant mortality rate and Enrollment rate I: Public expenditure on health and education (as a percent of GDP) Control variables: Fiscal decentralization (expenditure and revenue); Real GDP (in per capita terms); Natural resources (% GDP); Government fractionalization; Population size; Corruption Political System Index; Democracy; Autonomy	Expenditure decentralization seems to improve the efficiency of public service delivery in advanced economies but has a negative impact in emerging and developing countries. A sufficient degree of expenditure decentralization is required to bring about positive impacts.
Zhu and Peyrache (2017)	DEA	UK: 12 regions over the period 2000-2010 China: 31 provinces/ regions in 1999-2010	O (Education) : Total number of pupils on roll in both primary and secondary schools; number of teachers; student achievement indicator (UK); number of university students (China) O (Health): Population size; number of licensed doctors; number of hospital beds; total area of each region I: Real regional expenditure	The decentralized system (China) allocation of resources for public service delivery (the reallocation component) seems to be well addressed. This is mirrored by a highly disperse level of ITE across regions, which points to the possibility that best practices are not effectively enforced via decentralization. On the contrary, the centralized system (UK) is quite effective in pushing the adoption of best practices, as indicated by the low weight ITE has on overall country inefficiency; this comes at the expense of a high level of reallocation inefficiency: the UK (unlike China) seems to be less able to allocate resources efficiently across regions. There could be a potential trade-off between efficient resource allocation across regions and efficient delivery of public service at a regional level under different fiscal structures.
Stastna & Gregor (2015)	SFA	202 local governments/ municipalities	O: Pupils in kindergartens; pupils in kindergartens and primary schools; cultural facilities; municipal monuments; sports facilities; sporting and recreational area (ha); nature reserves; built-up area (ha); urban green area (ha); waste; businesses; roads (length, km), roads (size, ha); bus stops; homes for disabled; elderly population; municipal police; ratio district/municipality populations I: Total current spending, net of large mandatory payments on social transfers that are only disbursed by municipalities on behalf of the central government Control variables: Population; fiscal variables (e.g., capital expenditures per capita, self-generated revenues, and total subsidies per capita); geography; political indicators (e.g., the ideology of the mayor and position of the mayor in the municipal council);	Subsidies increase cost inefficiency, as predicted by the flypaper effect hypothesis. The share of self-generated revenues relaxes the budget contraint and increases cost inefficiency.

DEA and SFA employ different approaches to calculate the “frontier” of efficient combinations used for comparison (Hussey et al. 2009). DEA is a non-parametric[7] approach which involves mathematical programing based on observed data to estimate or infer the shape of best-practice frontiers and evaluate the relative efficiency of different units (Jacobs, Smith, and Street 2006; Bogetoft and Otto 2011). In particular, it constructs a non-parametric envelopment frontier over observed input and output data and subsequently calculates the efficiency of units relative to the frontier (Flegg et al 2003; Coelli 1996).

SFA is a parametric approach based on a priori assumptions on the structure of the production possibility set and the data generation process.[8] In this sense, SFA approach assumes that both are known a priori but the value of the parameters is unknown (Bogetoft and Otto 2011). The frontier is similar to the familiar regression model, which is based on the premise that a production function (or cost function) indicates the maximum output attainable given a set of inputs (or the minimum cost of producing that output given the prices of the inputs) [Greene 2008]. The estimation of the frontier functions involves econometric techniques[9] to estimate the parameters of a specific functional form of production (or cost) function (Jacobs, Smith, and Street 2006; Cornwell and Schmidt 2008; Kalb, Geys, and Heinemann 2012). It is guided by the theoretical proposition that “no observed/economic agent can exceed the ideal,” which means that “all observations lie within the theoretical extreme (Greene 2008, p.2; Belotti, Daidone, Ilardi, and Atella 2013, p. 720).”

Although SFA is like the conventional regression analysis, the error in the estimated function is decomposed into two components, namely inefficiency and two-sided random error or other stochastic influences (De Borger and Kerstens 1996; Jacobs, Smith, and Street 2006; Kalb, Geys, and Heinemann 2012; Belotti, Daidone, Ilardi, and Atella 2013).[10] Inefficiency is measured in terms of the units’ inability to achieve the theoretical ideal (Greene 2008), which is manifested by deviations or departures, i.e., how far each observation is from the frontier (Cornwell and Schmidt 2008; Kalb, Geys, and Heinemann 2012; Belotti, Daidone, Ilardi, and Atella 2013).[11] Nevertheless, such deviations or departures from the frontier may also reflect noise in the data/statistical noise (Bogetoft and Otto 2011; Mutter et al. 2012). In sum, SFA’s appealing feature compared to other methods is the presence of both an efficiency term and error term that allows for noise (Simar, Keilegom, and Zelenyuk 2014).

Despite the difference in methods (i.e., nonparametric and parametric approaches) used in constructing the frontier, DEA and SFA are both considered as analytically rigorous benchmarking approaches to measure efficiency relative to a frontier (Fried, Lovell, and Schmidt 2008). However, extant studies (e.g., Borger and Kerstens 1996; Daraio and Simar 2007; Simar and Wilson 2007) point out some methodological issues in the use of two-stage

[7] It does not assume or predetermine the functional form of the efficient frontier (Boetti, Piacenza, and Turati 2012; Seifert and Nieswand 2014), which indicates the maximum quantity of outputs that can be produced using available inputs (i.e., production frontier) and also, the minimum quantity of inputs that should be utilized to produce a certain level of output (i.e., cost frontier) [Hollingsworth 2008; Belotti, Daidone, Ilardi, and Atella 2013].

[8] Or functional form of the best-practice frontier (Boetti, Piacenza, and Turati 2012)

[9] Stochastic in nature which enables econometric approach to “attempt to distinguish the effects of noise from those of inefficiency, thereby providing the basis for statistical inference” (Fried, Lovell, and Schmidt 2008)

[10] Banker and Natarajan (2008) adopted a DEA-based stochastic frontier estimation framework which allowed for both one-sided inefficiency deviations and two-sided random noise.

[11] Aside from the estimation of the frontier, estimation of deviations from the frontier is another interest in modern efficiency analysis. However, inefficiency is unobservable and so estimates of efficiency have to be obtained indirectly based on observable phenomena such as measured inputs/outputs and the relationship between these phenomena (Jacobs, Smith, and Street 2006).

DEA (or two-stage approaches) wherein efficiency scores are estimated in the first stage using DEA.

Factors explaining efficiency are identified in the second stage through Tobit analysis (Afonso and Fernandes 2008; Lavado and Cabanda 2009; Da Cruz and Marques 2014; Drew, Kortt, and Dollery 2015; Ghani, Grewal, Ahmed, and Noor 2017; Tu, Lin, and Zhang 2018), bootstrapped truncated regression (Simar and Wilson 2011; Seifert and Nieswand 2014), Tobit censored regression (De Borger and Kerstens 1996), and boosted generalized linear mixed models (Bou-Hamad, Anouze, and Larocque 2017), among others with the end in view of accounting for exogenous/non-controllable factors that affect the units' performance (Simar and Wilson 2007).

In particular, studies that employed two-stage techniques failed to describe a coherent data-generating process, and consider complicated and unknown serial correlation among the estimated efficiencies which result in invalid inference (Simar and Wilson 2007; Daraio and Simar 2007; Balaguer-Coll et al. 2007; Da Cruz and Marques 2014; Seifert and Nieswand 2014). The exclusion of exogenous factors in the estimation of inefficiency scores in the first stage and regression of these scores on exogenous factors in the second stage yields severely biased results (Belotti, Daidone, Ilardi, and Atella 2013).[12] Bootstrap-based technique (Simar and Wilson 2007) was developed to obtain accurate inference but such approach relies on the separability condition (i.e., the environmental variables do not influence the shape or boundary of the production set [X, Y] but they affect efficiency) and also, regression in the second stage relies on some parametric assumptions (e.g., linear model and truncated normal error term) [Daraio and Simar 2005; Daraio and Simar 2007].

The separability condition is a restrictive assumption that is implicit (or not stated) in most existing studies that employ two-stage estimation. However, there are cases when the exogenous factors affect both the production set (X, Y) and efficiency (Simar and Wilson 2007; Simar and Wilson 2008) and thus, this should be addressed.[13] Conditional efficiency analysis[14] (Daraio and Simar 2005; Simar and Wilson 2007; Badin, Daraio, and Simar 2012) uses a general formulation of a nonparametric frontier model that includes external environmental factors that might affect the production process, thus avoiding the separability condition. Nevertheless, it requires a huge number of observations to obtain meaningful results (Seifert and Nieswand 2014).

[12] The use of outmoded two-stage estimation can result in inefficient or biased results (Rosko and Mutter 2008).

[13] The exogenous variables used in the first stage such as the output variables and prices should be uncorrelated with the second-stage exogenous variables in conducting two-stage procedure for it to obtain unbiased parameter estimates (De Borger and Kerstens 1996). Contextual variables should be independent of the input variables but they may be correlated with each other (Banker and Natarajan 2008).

[14] An alternative to two-step techniques that directly takes into account exogenous environmental factors in efficiency estimation, thus avoiding the assumption on the separability between the input-output space and the space of external factors (Badin and Daraio 2011; Seifert and Nieswand 2014); The study explored and attempted to use conditional efficiency analysis but due to limited sample size, such methodology could not be used.

3. Methodology and Data

3.1. Methodology

The study adopts Stochastic Frontier Analysis (SFA) to estimate the best-practice cost frontier, which indicates a lower bound to the expenditures C_i that is required to produce a given level of outputs for any observation *i*. In particular, it adopts Jacobs, Smith, and Street (2006)'s model given by the equation below:

$$C_i = \alpha + \beta_1 Y_{it} + \beta_2 X_{it} + \varepsilon_{it} \quad (1)$$
$$\varepsilon_{it} = v_{it} + u_{it}$$

i = 1,…,n observations or units and t = 1,…,T number of years

where

C_{it} – the cost (or expenditure) variable at time *i*
α – constant
β – captures the relationship between the dependent and explanatory variables Y and X
Y_{it} – information about different outputs that can be included as vector of explanatory variables at time *i*
X_{it} – vector of exogenous/non-controllable variables (e.g., socio-economic factors); referred to in Greene (2004) as covariates which affect the dependent variable rather than (in)efficiency at time *i*
ε_{it} – residual at time *i*
v_{it} – can be stochastic (random) events not under the control of the units, such as climatic conditions or errors in identifying or measuring explanatory variables or just pure chance

u_{it} – a non-negative term that captures the cost of inefficiency in production, defining how far the unit operates above the cost frontier

Given multiple outputs, it is more convenient to work with a cost function, which is a single dependent variable (Jacobs, Smith, and Street 2006) that incorporates all relevant input information (Seifert and Nieswand 2014). Also, LGU decision-makers and managers have more control over cost (or expenditure) as opposed to outputs, which in some cases are imposed on them and thus exogenous (Da Cruz and Marques 2014; Drew, Kortt, and Dollery 2015). Nevertheless, cost frontier is not widely used in efficiency analysis due to lack of reliable cost and price data (Belotti, Daidone, Ilardi, and Atella 2013).

The efficiency analysis covers a balanced panel of 54 or 37 provinces (i.e., consolidation of LGUs, including provinces and its component municipalities and cities but excluding highly urbanized cities/independent component cities)[15] depending on the outputs used and data availability in the period 2001-2013, except 2005 due to data unavailability. The study uses two datasets:

A. Panel of 54 provinces, including their respective component municipalities and cities to study the efficiency of LGU health spending using outputs as follows:

[15] Excluding the ARMM provinces (i.e., (i.e., Basilan, Sulu, Tawi-Tawi, Lanao del Sur, Maguindanao, and Shariff Kabunsuan) because the region follows a different organizational and governance structure as mandated in the Republic Act 6734 of 1989, i.e., An Act Providing for an Organic Act of the Autonomous Region in Muslim Mindanao

1. Access to hospital inpatient services (i.e., measured in terms of hospital bed capacity standardized to per 10,000 population; and
2. Health facility-based delivery (i.e., measured in terms of proportion of facility-based deliveries or percentage of births attended in health facilities);

B. Panel of 37 provinces, including their respective component municipalities and cities to study the efficiency of LGU health spending using outputs as follows:

   1. Access to hospital inpatient services;
   2. Access to safe water (i.e., measured in terms of proportion of households with access to safe water); and
   3. Access to sanitation (i.e., measured in terms of the proportion of households with access to sanitation).

The use of panel data allows the model to account for heterogeneity by introducing "individual (unobservable) effect" that is time-invariant and individual-specific (i.e., fixed effects model) and also, examine whether the inefficiency of units is time-varying or persistent (i.e., time-invariant) through time (Kumbhakar, Wang, and Horncastle 2015).[16] Although heterogeneity is not much of an issue in comparing provinces within a country (Lavado and Cabanda 2009), the study adopts fixed effects model (Greene 2004; Greene 2005a) to capture any unobserved effects that may vary across LGUs but do not change over time (e.g., geographic and cultural characteristics).

In this sense, Equation (1) can be reformulated based on Greene (2004) as:

$$C_{it} = (\alpha + u_i) + \beta_1 Y_{it} + \beta_2 X_{it} + v_{it} \qquad (2)$$
$$= \alpha_i + \beta_1 Y_{it} + \beta_2 X_{it} + v_{it}$$

$i = 1,\ldots,n$ observations or units and $t = 1,\ldots,T$ number of years

where $u_i = \max_i(\alpha_i) - \alpha_i \geq 0$.

The model in Equation (2) assumes that (i) any time-invariant heterogeneity will be pushed into α_i and ultimately into the estimate, $\hat{u}_i$; and (ii) inefficiency is time invariant. The latter is a reasonable assumption if considering short time intervals only. Also, fixed effects (as well as random effects) models fail to distinguish between cross-individual heterogeneity and inefficiency. In this regard, Greene (2004) proposes an alternative stochastic-frontier based method that distinguishes cross-unit heterogeneity and inefficiency and also, relaxes the assumptions for the fixed effects model given by Equation (2).
The proposed model adds country-specific constant terms (province-specific constant terms in this study) in the stochastic frontier model, thus making it "true" fixed effects model. Based on Greene (2004), Equation (2) can be reformulated as:

[16] See Schmidt and Sickles (1984), Jacobs, Smith, and Street (2006), and Cornwell and Schmidt (2008) for discussion on the advantages of panel data

$$C_{it} = \alpha_i + \beta_1 Y_{it} + \beta_2 X_{it} + v_{it} + u_{it} \quad (3)$$
$$E[U_i] = \mu_{it} = \delta_0 + \delta_{it} Z_{it}$$

i = 1,…,n observations or units and t = 1,…,T number of years

where Z are heterogeneity indicators that affect the mean of the inefficiency distribution. Equation (3) includes a full set of province dummy variables, which produce a neutral shift of the cost function for each unit. The "true" fixed effects model is fit by maximum likelihood, instead of least squares. It places the unmeasured heterogeneity in the cost function but in the final analysis, $\alpha_i + v_{it} + u_{it}$ comprises province-specific heterogeneity and inefficiency, which both may include invariant and time-varying elements based on Greene (2004).

The estimation of SF models can be done using official Stata routines such as xtfrontier, sfcross, and sfpanel, among others [Belotti, Daidone, Ilardi, and Atella 2013; Kumbhakar, Wang, and Horncastle 2015]. Nevertheless, such Stata routines do not perform natural logarithmic transformation of data and thus, users should do so before estimation (Stata Guide).

To estimate the cost frontier, the study adopts Kumbhakar, Wang, and Horncastle (2015) [hereafter KWH]'s author-written Stata commands for Model 8, i.e., true fixed-effects model based on Greene (2004) and Greene (2005a) using the logarithmic form of Equation (3), following De Borger and Kerstens (1996), Boetti, Piacenza, and Turati (2012), Belotti, Daidone, Ilardi, and Atella (2013), and Otsuka, Goto, and Sueyoshi (2014), among others. As Cornwell and Schmidt (2008, p. 700) put it, "the basic empirical framework for SFA is a regression specification involving a logarithmic transformation." KWH's Stata commands yield inefficiency estimates by Jondrow, Lovell, Materov, and Schmidt [hereafter JLMS] (1982) and also, efficiency estimates by Battese and Coelli [hereafter BC] (1988).

3.2. Data

Table 2 lists all the variables used and sources of data. The choice of variables is largely determined by availability of data at the LGU level for the years under study. Similar to De Borger and Kersterns (1996) and Boetti, Piacenza, and Turati (2012), the cost frontier model does not take into account variability in input prices because salary scales and allowances of LGU personnel are fixed and LGUs have access to the same market (i.e., including capital market).

The estimation of the cost frontier uses per capita LGU health spending as the dependent variable (i.e., cost/expenditure variable based on De Borger and Kerstens 1996; Boetti, Piacenza, and Turati 2012; Kalb, Geys, and Heinemann 2012; Belotti, Daidone, Ilardi, and Atella 2013; and Otsuka, Goto, and Sueyoshi 2014). The outputs are health services including hospital inpatient services, health-facility based delivery, access to safe water (Sampaio de Sousa and Stosic 2005; Afonso and Fernandes 2008), and access to sanitation.

Table 2. Summary of variables used in Stochastic Frontier Analysis

Variables	Description	Source
INPUT		
Per capita LGU health expenditure (in 2000 constant prices)	LGU health expenditure divided by the LGU population	Spending: Department of Finance-Bureau of Local Government Finance (DOF-BLGF)
		LGU Population: Department of Health (DOH) Field Health Services Information System (DOH FHSIS)
OUTPUTS		
Hospital bed to population ratio (per 10,000 population)	Levels of access to hospital inpatient services by the designated populations	Department of Health-Health Facilities and Services Regulatory Bureau (DOH-HFSRB)
	Measured in terms of hospital bed capacity standardized to per 10,000 population	LGU Population: DOH FHSIS
Health facility-based delivery	Measured in terms of proportion of facility-based deliveries or percentage of births attended in health facilities	DOH FHSIS
Access to safe water	Measured in terms of proportion of households with access to safe water	DOH FHSIS
Access to sanitation	Measured in terms of proportion of households with access to sanitation	DOH FHSIS
COVARIATES		
Per capita LGU income (in 2000 constant prices)	LGU income divided by LGU population	DOF-BLGF LGU Population: DOH FHSIS
Per capita own-source revenues (in 2000 constant prices)	LGU own-source revenue divided by LGU population	DOF-BLGF LGU Population: DOH FHSIS
Per capita IRA (in 2000 constant prices)	LGU internal revenue allotment divided by LGU population	DOF-BLGF LGU Population: DOH FHSIS
FACTORS AFFECTING EFFICIENCY		
Financial autonomy ratio (1)	LGU own-sourced revenue divided by LGU expenditures	DOF-BLGF
Financial autonomy ratio (2)	LGU own-sourced revenue divided by LGU income	DOF-BLGF
Health expenditure decentralization ratio	LGU health spending divided by General Government (GG) health spending, which is the combined health spending of the LGUs and National Government (DOH)	Author's estimates

Literature on determinants of health expenditure suggests that per capita gross domestic product/GDP or national income (Han, Cho, and Chun 2013; Liang and Mirelman 2013; Samadi and Rad 2013; Hosoya 2014; Akca, Sonmez, and Yilmaz 2017); proportion of population below 15 and above 65 years old (Samadi and Rad 2013); ratio of the population aged 65 and over to the total population (Hosoya 2014) or proportion of the elderly population (Han, Cho, and Chun 2013); urbanization (Samadi and Rad 2013); and population density as proxy for urbanization (Hosoya 2014) are factors driving health spending.

Due to data constraints, the study employs only the per capita LGU income (in 2000 constant prices), or its major components such as per capita IRA (i.e., block grants) and per capita own-source revenue (OSR) as covariates. Manasan (1997) and Manasan (2008) point out the positive correlation of per capita IRA and per capita OSR with LGU health spending, albeit the correlation between per capita OSR and LGU health spending is not significant in the case of provinces but it is strongly significant in the case of cities (Manasan 2008).

Correlation analysis done for this study explores the correlation between per capita health expenditures for all LGUs consolidated at the province level and these two covariates. Results indicate the strong positive correlation between per capita IRA and LGU health spending, and weak positive correlation between per capita OSR and LGU health spending (except for 2011 based on dataset with 54 observations) [Tables 3a and 3b].

Table 3a. Correlation between per capita LGU health expenditures and covariates (Dataset with 54 obs)

Year	Own-source revenues (In Per Capita Terms)	Internal revenue allotment (In Per Capita Terms)
2001	0.13	0.94
2002	0.12	0.92
2003	0.14	0.91
2004	0.16	0.92
2006	0.24	0.94
2007	0.20	0.93
2008	0.07	0.89
2009	0.02	0.87
2010	0.17	0.87
2011	-0.06	0.77
2012	0.04	0.86
2013	0.37	0.91

Source of raw data: DOF-BLGF

Table 3b. Correlation between per capita LGU health expenditures and covariates (Dataset with 37 obs)

	Own-source revenues (In Per Capita Terms)	Internal revenue allotment (In Per Capita Terms)
2001	0.51	0.95
2002	0.51	0.94
2003	0.57	0.93
2004	0.54	0.93
2006	0.57	0.94
2007	0.54	0.93
2008	0.41	0.89
2009	0.23	0.86
2010	0.44	0.82
2011	0.17	0.77
2012	0.29	0.89
2013	0.63	0.93

Source of raw data: DOF-BLGF

The identified drivers of efficiency (i.e., heterogeneity indicators affecting the mean of the inefficiency distribution) such as indicators of fiscal decentralization, namely financial autonomy ratio (i.e., in terms of the ratio between own-source revenue and LGU total expenditure, and ratio between own-source revenue and LGU total income) and health expenditure decentralization ratio (i.e., the main variable of interest in the study) are expected to reduce cost.

4. Analysis of Results

Tables 4a - 4b and Tables 5a - 5b present the estimation results for the cost frontier based on dataset with 54 observations and 37 observations, respectively. The estimated coefficients on access to hospital inpatient services are consistently positive and strongly significant in all models. The results suggest that improvement in access to hospital inpatient services increases LGU health spending which is as expected because of the huge cost associated with maintenance of hospitals.

The estimated coefficients on per capita LGU income are also positive which is consistent with existing literature on determinants of health expenditure. Those for per capita IRA are also positive which is consistent with the findings of Manasan (1997) and Manasan (2008). In contrast, the estimated coefficients on per capita own-source revenue are negative in all models which indicate that increase in own-source revenue of LGU may not be enough to finance LGU health service delivery, particularly maintenance of hospitals which is costly and thus, it is possibly used to finance less costly non-health spending items. In sum, the findings suggest that financing for health service delivery at the local level depends heavily on block grants.

Table 4a. Estimation results of cost frontier model: Part 1
Panel of 54 observations, 12 years

	Model 1 zvar = hedr	Model 2 zvar = far1	Model 3 zvar = far2	Model 4 zvar = hedr	Model 5 zvar = far1	Model 6 zvar = far2
Frontier						
Access to hospital inpatient services	0.3074 *** 0.0523	0.3197 *** 0.0536	0.3200 *** 0.0531	0.2568 *** 0.0528	0.2606 *** 0.0533	0.2566 *** 0.0534
Health facility-based delivery	0.0416 0.0254	0.0214 0.0252	0.0196 0.0252	0.0439 0.0231	0.0207 0.0220	0.0217 0.0220
Per capita own-source revenues				-0.0804 * 0.0403	-0.0831 * 0.0422	-0.1050 ** 0.0402
Per capita internal revenue allotment				0.4703 *** 0.0875	0.4748 *** 0.0889	0.4996 *** 0.0884
LGU per capita income	0.0254 ** 0.0504	0.1219 * 0.0499	0.1087 * 0.0501			
constant	4.1670 *** 0.3796	4.4332 *** 0.3762	4.6157 *** 0.3653	2.1714 *** 0.5760	2.2277 *** 0.5816	2.2195 *** 0.5825

*Significance: * p<0.05, ** p<0.01, *** p<0.001*

hedr	health expenditure decentralization ratio
far1	LGU own-source revenue/LGU expenditure
far2	LGU own-source revenue/LGU income

Table 4b. Estimation results of cost frontier model: Part 2
Panel of 54 observations, 12 years

	Model 1 zvar = hedr		Model 2 zvar = far1		Model 3 zvar = far2		Model 4 zvar = hedr		Model 5 zvar = far1		Model 6 zvar = far2	
var(u) zvar	7.4466	*	-6.0989		-7.5009		6.6594		-5.6714		30.4950	
	3.5358		4.7810		15.2332		3.9017		6.2639		30.1146	
var(u) constant	-11.0114	**	-3.4628	**	-5.3006		-10.7537	*	-4.5240	**	-20.6966	
	3.7687		1.2084		2.7847		4.2133		1.6470		16.2745	
var(v) constant	-3.1511	***	-3.1509	***	-3.0666	***	-3.1552	***	-3.1277	***	-3.0925	***
	0.0870		0.1732		0.0807		0.0766		0.0938		0.0556	
Marginal effect of zvar on E(u)	0.2900		-0.2602		-0.1282		0.2088		-0.1470		0.0286	
Marginal effect of zvar on V(u)	0.0303		-0.0274		-0.0054		0.0171		-0.0093		0.0014	
Log likelihood	76.5762		71.3250		69.4273		86.7460		82.7809		82.4019	
Estimates of inefficiency based on JLMS (1982)												
Mean	0.0780		0.0854		0.0342		0.0628		0.0519		0.0019	
SD	0.0384		0.0321		0.0102		0.0272		0.0159		0.0085	
Estimates of efficiency based on BC (1988)												
Mean	0.9272		0.9204		0.9668		0.9406		0.9503		0.9982	
SD	0.0340		0.0284		0.0097		0.0248		0.0148		0.0080	

*Significance: * p<0.05, ** p<0.01, *** p<0.001*

hedr — health expenditure decentralization ratio
far1 — LGU own-source revenue/LGU expenditure
far2 — LGU own-source revenue/LGU income

Table 5a. Estimation results of cost frontier model: Part 1
Panel I of 37 observations, 12 years

	Model 1 zvar = hedr		Model 2 zvar = far1		Model 3 zvar = far2		Model 4 zvar = hedr		Model 5 zvar = far1		Model 6 zvar = far2	
Frontier												
Access to hospital inpatient services	0.2117	***	0.2251	***	0.2297	***	0.1717	**	0.1796	**	0.1806	**
	0.0602		0.0617		0.0612		0.0605		0.0612		0.0608	
Households with access to safe water	-0.0413		-0.0362		-0.0358		-0.0486		-0.0448		-0.0445	
	0.0378		0.0391		0.0391		0.0368		0.0378		0.0377	
Households with access to toilet	0.0245		0.0254		0.0236		0.0415		0.0411		0.0396	
	0.0433		0.0434		0.0436		0.0423		0.0424		0.0425	
Per capita own-source revenues							-0.0587		-0.0813		-0.0880	*
							0.0451		0.0459		0.0446	
Per capita internal revenue allotment							0.5689	***	0.5685	***	0.5862	***
							0.0966		0.0985		0.0995	
LGU per capita income	0.2183	***	0.1705	***	0.1686	***						
	0.0446		0.0403		0.0401							
constant	3.9342	***	4.2823	***	4.3036	***	1.5198	*	1.6205	*	1.5240	*
	0.4396		0.4204		0.4176		0.6758		0.6796		0.6852	

*Significance: * p<0.05, ** p<0.01, *** p<0.001*

hedr — health expenditure decentralization ratio
far1 — LGU own-source revenue/LGU expenditure
far2 — LGU own-source revenue/LGU income

Table 5b. Estimation results of cost frontier model: Part 2
Panel I of 37 observations, 12 years

	Model 1 zvar = hedr	Model 2 zvar = far1	Model 3 zvar = far2	Model 4 zvar = hedr	Model 5 zvar = far1	Model 6 zvar = far2
var(u) zvar	2.0255 *	-1.0662	0.7046	1.2390	0.1402	1.9163
	0.9251	1.7868	2.1870	0.7751	1.7386	2.1159
var(u) constant	-4.5927 ***	-2.7171 ***	-2.9620 ***	-3.8862 ***	-2.8789 ***	-3.0981 ***
	0.9131	0.3702	0.3781	0.7284	0.3721	0.3740
var(v) constant	-3.7107 ***	-3.7164 ***	-3.7292 ***	-3.8400 ***	-3.8402 ***	-3.8520 ***
	0.2112	0.2049	0.2011	0.2126	0.2117	0.2092
Marginal effect of zvar on E(u)	0.1878	-0.1005	0.0669	0.1179	0.0134	0.1842
Marginal effect of zvar on V(u)	0.0406	-0.0217	0.0145	0.0258	0.0029	0.0406
Log likelihood	66.9889	64.2974	64.1655	77.7629	76.4256	76.8264
Estimates of inefficiency based on JLMS (1982)						
Mean	0.1827	0.1859	0.1871	0.1871	0.1882	0.1891
SD	0.1069	0.1051	0.1067	0.1118	0.1107	0.1125
Estimates of efficiency based on BC (1988)						
Mean	0.8414	0.8387	0.8378	0.8380	0.8370	0.8364
SD	0.0782	0.0774	0.0783	0.0815	0.0811	0.0823

*Significance: * p<0.05, ** p<0.01, *** p<0.001*

hedr	health expenditure decentralization ratio
far1	LGU own-source revenue/LGU expenditure
far2	LGU own-source revenue/LGU income

The variance parameters are significant in all models except for the variance parameter on zvar, which is only significant in Model 1 of Tables 4b and 5b wherein covariate considered is per capita LGU income and zvar used is hedr, which has direct impact on health service delivery as compared to the other zvars (i.e., financial autonomy ratios). The positive marginal effect of hedr on V[u] indicates that hedr, as measure of health devolution increases the variance of inefficiency by 3 percent and 4 percent based on Table 4b and Table 5b, respectively.

The positive marginal effect of hedr on E[u] implies that hedr increases the mean inefficiency and in turn, the cost of health service delivery (i.e., on average, by 29 percent and 19 percent based on Model 1 in Table 4b and Table 5b, respectively). The average efficiency is estimated to be around 93 percent based on dataset of 54 observations and about 84 percent based on dataset of 37 observations. Efficient units are expected to have 100% efficiency index. An efficiency index of 93 percent (84%) indicates that a 7% (16%) cost reduction is feasible. The average inefficiency is estimated to be around 8 percent based on dataset of 54 observations and about 18 percent based on dataset of 37 observations.

5. Concluding Remarks

The findings of the stochastic frontier analysis provide empirical evidences on the efficiency implications of health devolution. In particular, health devolution as measured by the health expenditure decentralization ratio has positive effect on the mean of the inefficiency distribution, thus adding unnecessary cost. Such findings are not as expected because one of the theoretical benefits of fiscal decentralization (or health devolution) is efficiency. As emphasized earlier, efficiency is the major underlying argument for fiscal decentralization.

Nevertheless, the findings are consistent with what the literature says about the health devolution experience in the country. Issues on mismatch between local government fiscal capacity and devolved functions, fragmentation of health system, existence of two-track delivery system, and unclear expenditure assignments, among others inevitably creates inefficiency. Moreover, the study recognizes that other factors (e.g., elite capture, rent-seeking interests, and corruption) also affect efficiency of health service delivery. These issues should be addressed to fully reap the potential benefits, particularly efficiency gains from fiscal decentralization (or health devolution).

The recent development on the Supreme Court’s final ruling that local governments’ share in internal revenue allotment (IRA) should be based on all national taxes (i.e., not only national internal revenue taxes, which have been the source of IRA since 1992) will surely improve the fiscal capacity of the local governments. However, whether or not local governments will prioritize health given the fiscal space remains to be seen.

On the other hand, the passage of the Universal Health Care Act (UHCA) of 2019 addresses the issue of fragmentation of health system as it stipulates the integration of local health systems such as health offices, facilities, and services, human resources, and other operations relating to health under LGUs’ management, into province-wide health systems and city-wide health systems. The integrated health systems should be linked to at least one apex or end-referral hospital.

As specified in Section 17.2 of the UHCA Implementing Rules and Regulations (IRR), the DOH shall endeavor to contract province-wide and city-wide health systems through a legal instrument to ensure shared responsibilities and accountabilities among members of the health system for the delivery of population-based health services,[17] particularly those that have impact on the social determinants of health. Section 19.9 of the IRR stipulates that LGUs that commit to province-wide or city-wide integration shall ensure managerial and financial integration and provide the needed resources and support mechanisms to make the integration possible and sustainable.

Other issues concern the design of health devolution, which is crucial in bringing about efficiency gains from fiscal decentralization. Economic literature suggests key elements of a well-designed decentralization policy: (i) the appropriate assignment of expenditure responsibilities across levels of government; (ii) and unambiguous and clear assignment of functions. It is deemed critical to revisit/review the Local Government Code’s Section 17 (c) and 17(f), which encourage the existence of two-track delivery system, thus bringing about confusion and weak accountability between levels of government and also, inefficiencies in health service delivery.

[17] Province-wide and city-wide health systems shall deliver both population-based and individual-based health services (Section 19.8 of UHCA IRR).

6. References

Aberilla, Niño and Enrico C. Yee, Jr. 2016. Technical Efficiency of Water Districts in the Province of Davao del Sur: A Data Envelopment Approach. *Univ. of Min. Intl. Mult. Res. Jour.*, 1(2): 85-94.

Adam, Antonis, Manthos Delis, and Pantelis Kammas. 2014. Fiscal Decentralization and Public Sector Efficiency: Evidence from OECD Countries. *Econ Gov*, 15:17–49.

Afonso, Antonio and Sonia Fernandes. 2008. Assessing and Explaining the Relative Efficiency of Local Government. *The Journal of Socio-Economics*, 37: 1946-1979.

Akca, Nesrin, Seda Sonmez, and Ali Yilmaz. 2017. Determinants of Health Expenditure in OECD Countries: A Decision Tree Model. *Pakistan Journal of Medical Sciences*, 33(6): 1490–1494.

Alinsunurin, Maria Kristina. 2014. Efficiency of Microfinance Institutions in the Philippines. Enterprise *Development and Microfinance,* 25(4): 311-324.

Ampit, Cheryl and Agustina Tan-Cruz. 2007. Cost Efficiency Estimation of State Universities and Colleges in Region XI. Paper presented during the 10th National Convention on Statistics at Edsa Shangrila Hotel on October 1-2, 2007.

Atienza, Maria Ela. 2004. The Politics of Health Devolution in the Philippines: Experiences of Municipalities in a Devolved Set-up. *Philippine Political Science Journal*, 25 (48): 25-54.

Badin, Luiza and Cinzia Daraio. 2011. Explaining Efficiency in Nonparametric Frontier Models: Recent Developments in Statistical Inference. In Exploring Research Frontiers in Contemporary Statistics and Econometrics: A Festschrift for Leopold Simar, edited by Ingrid Van Keilegom and Paul W. Wilson. Heidelberg: Springer-Verlag.

Badin, Luiza, Cinzia Daraio, and Leopold Simar. 2012. How to Measure the Impact of Environmental Factors in a Nonparametric Production Model. *European Journal of Operational Research*, 223: 818-833.

Balaguer-Coll, Maria Teresa, Diego Prior, and Emili Tortosa-Ausina. 2007. On the Determinants of Local Government Performance: A Two-Stage Nonparametric Approach. *European Economic Review*, 15:425-451.

_ _ _. 2010. Decentralization and Efficiency of Local Government. *Ann Reg Sci*, 45:571–601.

Baldemor, Milagros. 2018. Efficiency of Local Government Units in Northwestern Philippines as to the Attainment of the Millennium Development Goals. Paper presented during the DEA40 International Conference on Data Envelopment Analysis at Aston Business School, Birmingham, UK on April 16-18, 2018.

Banker, Rajiv and Ram Natarajan. 2008. Evaluating Contextual Variables Affecting Productivity Using Data Envelopment Analysis. *Operations Research*, 56(1): 48-58.

Barankay, Iwan and Ben Lockwood. 2007. Decentralization and the Productive Efficiency of Government: Evidence from Swiss Cantons. *Journal of Public Economics*, 91: 1197-1218.

Battese, George and Tim Coelli. 1988. Prediction of Firm-Level Technical Efficiencies with a Generalized Frontier Production Function and Panel Data. *Journal of Econometrics*, 38: 387–99.

Boetti, Lorenzo, Massimiliano Piacenza and Gilberto Turati. 2012. Decentralization and Local Governments' Performance: How Does Fiscal Autonomy Affect Spending Efficiency? *Public Finance Analysis*, 68(3): 269-302.

Bogetoft, Peter and Lars Otto. 2011. Benchmarking with DEA, SFA, and R. International Series in Operations Research & Management Science 157, DOI 10.1007/978-1-4419-7961-2_1.

Bou-Hamad, Imad, Abdel Latef Anouze, and Denis Larocque. 2017. An Integrated Approach of Data Envelopment Analysis and Boosted Generalized Linear Mixed Models for Efficiency Assessment. *Ann Oper Res*, 253: 77-95.

Castano, Mary Caroline and Emilyn Cabanda. 2007. Performance Evaluation of the Efficiency of Philippine Private Higher Educational Institutions: Application of Frontier Approaches. *Intl. Trans. in Op. Res.*, 14: 431–444.

Chen, Shiyi and Jun Zhang. 2009. Empirical Research on Fiscal Expenditure Efficiency of Local Governments in China: 1978–2005. *Social Sciences in China*, 30(2): 21-34.

Coelli, Tim. 1996. A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program. CEPA Working Paper 96/8. Centre for Efficiency and Productivity Analysis. Department of Econometrics. University of New England. Armidale New South Wales, Australia.

Cornwell, Christopher and Peter Schmidt. 2008. Stochastic Frontier Analysis and Efficiency Estimation. In Advanced Studies in Theoretical and Applied Econometrics, The Econometrics of Panel Data: Fundamentals and Recent Developments in Theory and Practice, edited by Laszlo Matyas and Patrick Sevestre. Germany: Springer.

Cuenca, Janet. 2011. Efficiency of State Universities and Colleges in the Philippines: A Data Envelopment Analysis. PIDS Discussion Paper No. 2011-14. Makati City: Philippine Institute for Development Studies.

_ _ _. 2013. Efficiency of State Universities and Colleges in the Philippines: A Data Envelopment Analysis. Special Paper in the Analysis of the President's Budget for 2012: Financing of State Universities and Colleges authored by Rosario G. Manasan. PIDS Book 2013-01.

Da Cruz, Nuno and Rui Marques. 2014. Revisiting the Determinants of Local Government Performance. *Omega*, 44: 91–103.

Daraio, Cinzia and Leopold Simar. 2005. Introducing Environmental Variables in Nonparametric Frontier Models: A Probabilistic Approach. *Journal of Productivity Analysis*, 24: 93-121.

_ _ _. 2007. Advanced Robust and Nonparametric Methods in Efficiency Analysis: Methodology and Applications.

De Borger, Bruno and Kristiaan Kerstens. 1996. Cost Efficiency of Belgian Local Governments: A Comparative Analysis of FDH, DEA, and Econometric Approaches. *Regional Science and Urban Economics*, 26: 145-170.

De Nicola, Arianna, Simone Gitto, Paolo Mancuso1, and Vivian Valdmanis. 2014. *The International Journal of Health Planning and Management*, 2014: 29: e48–e63.

Department of Health (DOH). 1999a. National Objectives for Health 1999-2004. Manila: Department of Health.

_ _ _. 1999b. Health Sector Reform Agenda 1999-2004. Monograph Series No. 2. Manila: Department of Health.

_ _ _. 2005. National Objectives for Health 2005-2010. Manila, Philippines: Department of Health.

Digal, Larry, Hazel Shayne Ramil, Shemaiah Gail Placencia, and Carol Balgos. 2017. Efficiency of Municipal Fisherfolk in Maasim, Saranggani Province, Philippines: A Stochastic Frontier and Data Envelopment Approach. *Asian Fisheries Science,* 30:169−184

Dorotan, Eddie G. and Zsolt Mogyorosy. 2004. Making Your Local Health System Work: A Resourcebook on the Local Health System Development.

Drew, Joseph, Michael Kortt, and Brian Dollery. 2015. What Determines Efficiency in Local Government? A DEA Analysis of NSW Local Government. *Economic Papers*, 34(4): 243-256.

Ebel, Robert and Serdar Yilmaz. 2004. On the Measurement and Impact of Fiscal Decentralization. World Bank Policy Research Working Paper No. 2809. World Bank.

Flegg, AT, DO Allen, K Field, and TW Thurlow. 2003. Measuring the Efficiency and Productivity of British Universities: An Application of DEA and the Malmquist Approach. DAEF Working Paper No. 0304. Bristol: Department of Accounting, Economics and Finance

Fried, Harold, C.A. Knox Lovell, and Shelton Schmidt. 2008. Efficiency and Productivity. In The Measurement of Productive Efficiency and Productivity Change, edited by Harold O. Fried, C. A. Knox Lovell, and Shelton S. Schmidt. New York: Oxford University Press.

Galvez-Tan, Jaime et al. 2010. Development of an Essential Health Package. World Health Organization.

Gayosa, Eduardo and Emilyn Cabanda. 2014. Frontier Analysis of the Philippine Manufacturing Efficiency. *Int. J. Information and Decision Sciences*, 6(1): 87-108.

Ghani, Judhiana, Bhajan Grewal, Abdullahi Ahmed, and Norashidah Mohd Noor. 2017. Efficiency Analysis of State Governments in the Malaysian Fiscal Federalism. *Int. Journal of Economics and Management*, 11(2): 449 – 466.

Gonzalez, Eduardo. 1996. Intergovernmental Fiscal Relations: An Institutional Analysis. In Developing an Action Plan for Financing of Local Government Projects with Social and Environmental Objectives, Vol. 2, Institutional and Sectoral studies, edited by R.P. Alonzo. Quezon City: University of the Philippines School of Economics Foundation.

Greene, William. 2004. Distinguishing Between Heterogeneity and Inefficiency: Stochastic Frontier Analysis of the World Health Organization’s Panel Data on National Health Care Systems. *Health Economics*, 13: 959-980.

_ _ _. 2005a. Fixed and Random Effects in Stochastic Frontier Models. *Journal of Productivity Analysis*, 23: 7–32.

_ _ _. 2005b. Reconsidering Heterogeneity in Panel Data Estimators of the Stochastic Frontier Model. Journal of Econometrics, 126: 269–303.

_ _ _. 2008. The Econometric Approach to Efficiency Analysis. In The Measurement of Productive Efficiency and Productivity Change, edited by Harold O. Fried, C. A. Knox Lovell, and Shelton S. Schmidt. New York: Oxford University Press.

Grundy, J., V. Healy, L. Gorgolon, and E. Sandig. 2003. Overview of Devolution of Health Services in the Philippines. *The International Electronic Journal of Rural and Remote Health Research, Education, Practice and Policy*.

Han, Kimyoung, Minho Cho, and Kihong Chun. Determinants of Health Care Expenditures and the Contribution of Associated Factors: 16 Cities and Provinces in Korea, 2003-2010. *Journal of Preventive Medicine and Public Health*, 46: 300-308.

Hollingsworth, Bruce. 2008. The Measurement of Efficiency and Productivity of Health Care Delivery. *Health Economics*, 17: 1107-1128.

Hosoya, Kei. 2014. Determinants of Health Expenditures: Stylized Facts and a New Signal. *Modern Economy*, 5: 1171-1180.

Hussey, Peter, Han de Vries, John Romley, Margaret C. Wang, Susan S. Chen, Paul G. Shekelle, and Elizabeth A. McGlynn. 2009. A Systematic Review of Health Care Efficiency Measures. Health Research and Educational Trust. *Health Services Research*, 44(3): 784-805.

Jacobs, Rowena, Peter Smith, and Andrew Street. 2006. Measuring Efficiency in Health Care: Analytical Techniques and Health Policy. New York: Cambridge University Press.

Jondrow, James, C.A. Knox Lovell, Ivan Materov and Peter Schmidt. 1982, On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model. *Journal of Econometrics*, 19: 233-238.

Kahkonen, Satu and Anthony Lanyi. 2001. Decentralization and Governance: Does Decentralization Improve Public Service Delivery? PREM Notes No. 55. The World Bank.

Kalb, Alexander, Benny Geys, and Friedrich Heinemann. 2012. Value for Money? German Local Government Efficiency in a Comparative Perspective. *Applied Economics*, 44(2): 201-218.

Kumbhakar, Subal, Hung-Jen Wang, and Alan Horncastle. 2015. A Practitioner's Guide to Stochastic Frontier Analysis Using Stata. Cambridge: Cambridge University Press.

Lamberte, Mario and Martin Desrocher. 2002. Efficiency and Expense Preference in the Philippines' Cooperative Rural Banks. PIDS Discussion Paper No. 2002-12. Makati City: Philippine Institute for Development Studies.

Lavado, Rouselle. 2004. Alternative Methods of Benchmarking the Efficiency of Philippine Electric Cooperatives. Paper presented during the 9th National Convention on Statistics at Edsa Shangrila Hotel on October 4-5, 2004.

Lavado, Rouselle and Erniel Barrios. 2008. Spatial-Temporal Dimensions of Efficiency among Electric Cooperatives in the Philippines. PIDS Discussion Paper No. 2008-29. Makati City: Philippine Institute for Development Studies.

Lavado, Rouselle and Emilyn Cabanda. 2009. The Efficiency of Health and Education Expenditures in the Philippines. *Central European Journal of Operations Research*, 17: 275-291.

Lavado, Rouselle, Leizel Lagrada, and Brian Gozun. 2010. Using DEA to Assess the Efficiency of Public Health Units in Providing Health Care Services. *Applications in Multicriteria Decision Making, Data Envelopment Analysis, and Finance*, 14: 237-248.

Liang, Li-Lin and Andrew Mirelman. 2013. Why Do Some Countries Spend More for Health? An Assessment of Sociopolitical Determinants and International Aid for Government Health Expenditures. Health, Nutrition, and Population Discussion Paper. World Bank: Washington DC.

Liu, Jianmin, Xiaomei Hu, and Hongli Tang. 2016. Fiscal Decentralization and Regional Financial Efficiency: An Empirical Analysis of Spatial Durbin Model. *Discrete Dynamics in Nature and Society*, 2016:1-14.

Loehr, William and Rosario Manasan. 1999. Fiscal Decentralization and Economic Efficiency: Measurement and Evaluation. CAER II Discussion Paper No. 38. Consulting Assistance on Economic Reform II. United States Agency for International Development.

lo Storto, Corrado. 2013. Evaluating Technical Efficiency of Italian Major Municipalities: A Data Envelopment Analysis Model. *Social and Behavioral Sciences*, 81: 346 – 350.

Manasan, Rosario. 1997. Local Government Financing of Social Service Sectors in a Decentralized Regime: Special Focus on Provincial Governments in 1993 and 1994. PIDS Discussion Paper Series No. 97-04. Makati City: Philippine Institute for Development Studies.

_ _ _. 2005. Local Public Finance in the Philippines: Lessons in Autonomy and Accountability. *Philippine Journal of Development*, 60(2): 31-102.

_ _ _. 2008. Policy Study on the National and Local Government Expenditures for Millennium Development Goals, 2000-2005. PIDS Discussion Paper Series No. 2008-17. Makati City: Philippine Institute for Development Studies.

Martínez, Yolanda, Pedro Arzoz, and Belén Apezteguía. 2018. Does Decentralization Contribute to Efficiency? Evidence from OECD countries. *Applied Economics*, 50(7): 726-742.

Mutter, Ryan, William Greene, William Spector, Michael Rosko, and Dana Mukamel. 2012. Investigating the Impact of Endogeneity on Efficiency Estimates in the Application of Stochastic Frontier Analysis to Nursing Homes. *J Prod Anal*, 39: 101-110.

Oates, Wallace E. 1972. Fiscal Federalism. New York: Harcourt Brace Jovanovich.

_ _ _. 2006. On the Theory and Practice of Fiscal Decentralization. IFIR Working Paper No. 2006-05. Lexington City: Institute for Federalism & Intergovernmental Relations.

Otsuka, Akihiro, Mika Goto, and Toshiyuki Sueyoshi. 2014. Cost-efficiency of Japanese Local Governments: Effects of Decentralization and Regional Integration. *Regional Studies, Regional Science*, 1(1): 207-220

Romualdez, Alberto, Jennifer Frances dela Rosa, Jonathan David Flavier, Stella Luz Quimbo, Kenneth Hartigan-Go, Liezel Lagrada and Lilibeth David. 2011. The Philippines Health Systems Review. Health Systems in Transition Vol. 1 No. 2. World Health Organization.

Rosko, Michael and Ryan Mutter. 2008. Stochastic Frontier Analysis of Hospital Inefficiency: A Review of Empirical Issues and an Assessment of Robustness. *Medical Care Research and Review*, 65(2): 131-165.

Samadi, Alihussein and Enayatollah Homaie Rad. 2013. Determinants of Healthcare Expenditure in Economic Cooperation Organization (ECO) Countries: Evidence from Panel Cointegration Tests. *International Journal of Health Policy and Management*, 1(1): 63-68.

Sampaio De Sousa, Maria Da Conceicao and Borko Stosic. 2005. Technical Efficiency of the Brazilian Municipalities: Correcting Nonparametric Frontier Measurements for Outliers. *Journal of Productivity Analysis*, 24: 157–181.

Schmidt, Peter and Robin Sickles. 1984. Production Frontiers and Panel Data. *Journal of Business & Economic Statistics*, 2(4): 367-374.

Seifert, Stefan and Maria Nieswand. 2014. What Drives Intermediate Local Governments' Spending Efficiency: The Case of French Departements. *Local Government Studies*, 40(5): 766-790.

Simar, Leopold. 1992. Estimating Efficiencies from Frontier Models with Panel Data: A Comparison of Parametric, Non-Parametric and Semi-Parametric Methods with Bootstrapping. The *Journal of Productivity Analysis*, 3: 171-203.

Simar, Leopold, Ingrid Van Keilegom, and Valentin Zelenyuk. 2014. Nonparametric Least Squares Methods for Stochastic Frontier Models. CEPA Working Paper Series No. WP03/2014. Queensland: Centre for Efficiency and Productivity Analysis.

Simar, Leopold and Paul Wilson. 2000. Statistical Inference in Nonparametric Frontier Models: The State of the Art. *Journal of Productivity Analysis,* 13: 49-78.

_ _ _. 2007. Estimation and Inference in Two-Stage, Semi-Parametric Models of Production Processes. *Journal of Econometrics*, 136: 31–64.

_ _ _. 2008. Statistical Inference in Nonparametric Frontier Models: Recent Developments and Perspectives. In The Measurement of Productive Efficiency and Productivity Change, edited by Harold O. Fried, C. A. Knox Lovell, and Shelton S. Schmidt. New York: Oxford University Press.

_ _ _. 2011. Two-stage DEA: Caveat Emptor. *J Prod Anal*, 36:205–218:

Solon, Jose Orville and Alejandrino Herrin. 2017. The Challenge of Reaching the Poor with a Continuum of Care: A 25-Year Assessment of Health Sector Performance. In Risks, Shocks, Building Resilience. Proceedings of the Second Annual Public Policy Conference 2016. Philippine Institute for Development Studies and Bangko Sentral ng Pilipinas.

Sow, Mousse and Ivohasina F. Razafimahefa. 2015. Fiscal Decentralization and the Efficiency of Public Service Delivery. IMF Working Paper No. 1559. International Monetary Fund.

Stastna, Lenka and Martin Gregor. 2015. Public Sector Efficiency in Transition and Beyond: Evidence from Czech Local Governments. *Applied Economics,* 47(7): 680-699.

Tu, Bin, Ying-Xian Lin, and Yi-Meng Zhang. 2018. Efficiency Evaluation and Influencing Factors Analysis of Governmental Expenditure on Preschool Education. *EURASIA Journal of Mathematics, Science and Technology Education*, 14(6): 2533-2543.

Valderrama, Helena Agnes and Carlos Bautista. 2009. Efficiency Analysis of Electric Cooperatives in the Philippines. Unpublished.

World Bank (WB). 1993. World Bank Development Report 1993: Investing in Health. New York: Oxford University Press.

_ _ _. 1994. Philippine Devolution and Health Services: Managing Risks and Opportunities. Manila: World Bank.

_ _ _.2010. Approach Paper on a World Bank Strategy for Supporting Decentralization Reforms.

_ _ _. 2011. Philippines: Study on Local Service Delivery. Manila: The World Bank.

Zhu, Minyan and Antonio Peyrache. 2017. The Quality and Efficiency of Public Service Delivery in the UK and China. *Regional Studies*, 51(2): 285-296.