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Water and clean energy services in developing countries: Regulation and evaluation of universal service policies

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PhD in Economics | Àlex Sanz Fernández

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Agathos – "Ah, not in knowledge is happiness, but in the acquisition of knowledge! In for ever knowing, we are for ever blessed; but to know all were the curse of a fiend."

The Power of Words. Edgar Allan Poe.

Per l'Emma.

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Chapter I: Introduction

1 Motivation

Water is essential for human life. But the amount of fresh water on earth is limited. Although two thirds of the earth's surface is covered by water, only 1% is fresh water. Moreover, 1.2 billion people live in areas where water is scarce, which has a negative impact on their life's quality. Without access to safe water, many communities suffer from water-related diseases that can lead to higher mortality or morbidity. Additionally, the time spent collecting water reduces the opportunity to carry out other activities like studying or working, which affects the future wellbeing of many families. Improving the access to safe water not only saves human lives, but also improves education of children, reduces health-care expenses and improves economic productivity.

WHO has shown in several studies that access to water and sanitation services is fundamental for improving global health. In 2008, access to safe water could have prevented near 2.7 million deaths in children worldwide, half of the cases due to diarrhoeal problems. Moreover, access to safe water can prevent being seriously disabled due to lymphatic filariasis and trachoma. WHO has calculated that each year 10 million people get seriously affected by these diseases. So, having access to safe water and sanitation could improve the lives of near 13 million people each year. This is because 9.1% of burden of disease worldwide could be prevented by improvements related to safe water and sanitation. Also, 6.3% of all deaths could be prevented by improving access to safe water and sanitation (WHO 2008).

In 1977, United Nations 'Water Conference' at Mar de la Plata set up an International Drinking Water Decade, 1981-1990, with the objective to make access to safe drinking water available across the world.[1] Although the

[1] In the last decades, several international organizations have included the support to the construction and management of water systems in their agendas. The Inter-American Development Bank (IDB) is the largest funding agent in Latin America and the Caribbean, and promotes the construction of water systems and the technical assistance to water managers in cities with less than of 50,000 inhabitants, focusing on poor communities. It also helps rural communities to have access to funding and technical assistance to operate their water systems. The Global Water Partnership (GWP) is an international network which supports countries in the development of Integrated Water Resources Management (IWRM). The World Bank finances projects to increase access to water services both in rural and urban areas of developing countries.

objective of easing access to safe water and sanitation for everybody at 1990 was not attained, this was the first relevant attempt to guarantee universal access to the service. Just at the end of the 80s, WHO and UNICEF created the Joint Monitoring Programme for Water Supply and Sanitation (JMP) in order to report globally on the status of water and sanitation sector and to support countries to improve the performance of their water systems.

The importance of water for economic development was finally highlighted by the UN in September 2000, after world leaders adopted the Millennium Declaration. The main objective of the Declaration was to reduce extreme poverty in the world. After this Declaration, the UN established the Millennium Development Goals (MDG).[2] The main objective was to reduce extreme poverty achieving eight goals by 2015. Within these Goals, the importance of access to safe water was highlighted in the objective number 7. In particular, the goal was to halve, by 2015, the proportion of population without sustainable access to safe drinking water and basic sanitation. This objective is also related with the Goal number 4, which consists in the reduction of child mortality. Indeed, access to safe water reduces the probability of being ill due to water-related diseases, which is one of the main causes of morbidity and mortality in children under five years in developing countries.

From 2000 to date there has been a huge increase of water coverage in the world, and the objective established in the MDG was met 5 years before the deadline. Also, between 1990 and 2015, 2.6 billion people gained access to improved drinking water and 2.1 billion people gained access to improved sanitation. Moreover, between 1990 and 2015 the global mortality rate of children under five years has declined from 90 to 43 deaths per 1000 live births, reducing the number of deaths to 6 million per year at 2015. Results are much less positive in rural areas, where children under five years are about 1.7 times more likely to die than those living in urban areas. Although in the last decade many countries have made important progress to attain the MDG's, nowadays, still 16,000 children under five years die every day mostly from preventable causes.

In addition to water, access to energy can also improve the quality of life of rural population worldwide. As UN(2005) noted, energy services are related with almost all MDG's because having access to energy services has a multiplier effect on health, education, transport, telecommunications, safe water and

[2] United Nations. Millennium Development Goals. http://www.un.org/millenniumgoals/

sanitation. Moreover, the use of solid biomass for indoor cooking has been reported as being one of the main drivers of respiratory diseases in developing countries, especially in the case of children and women, who spend more time at home.[3] In addition, the use of inefficient cookstoves reduces the time that women and children can allocate for productive or educational activities, since they have to dedicate a lot of their daily time for cooking and gathering fuel.

It is estimated that 1.2 billion people worldwide lack access to electricity while more than twice depend on biomass (wood, agricultural waste, dung) for cooking (Bonjour et al. 2013). Although the 71.77% of the world population living in rural areas has access to electricity, this value is reduced to 69.34% if we focus on those countries whose incomes per capita are considered medium or low. Moreover, there is much dispersion between different countries and regions. Developing countries of the Pacific and East Asia have a rural coverage of 92.80%, similar to that of the developing countries in Latin America (86.10%) or Middle East and North Africa (90%). However, Sub-Saharan African countries have a limited coverage of 15.32%. This area encompasses the countries with the lowest rural coverage. In addition, rural population of developing countries relies on a combination of pollutant and modern fuels for energy purposes like cooking or heating.

Taking this into account, improving access to clean fuels and non-polluting stoves is also a key policy for improving health and living conditions of the population of developing countries, mainly in rural areas. International organizations have created programs to increase energy access worldwide. For example, World Bank has 368 active programs in the energy sector, being Africa the region with the most active programs (131). From this 368 programs, 85 are devoted to improve rural services and infrastructure, and more than a half, 44, are carried out in Africa, like AFREA, which aims to help to meet the needs and widen access to energy services in Sub-Saharan African countries in an environmentally responsible way.

In the case of cookstoves, from a pool of 87 developing countries, 14 have launched initiatives to substitute inefficient cookstoves for improved ones (UN.

[3]ESMAP (2002, 2003a, 2004) explains the close relationship between fuel type, kitchen type and kitchen ventilation with the exposure to particulate matter. The smoke produced during the combustion of solid fuels contains pollutants (particulates, carbon monoxide, formaldehyde, etc.). Also, exposition to particulates less than 10 microns in diameter (small particulates) is a risk factor for acute respiratory infections (ARI) and for acute lower respiratory infections (ALRI). Small particulates are also related with chronic bronchitis and chronic obstructive pulmonary disease.

2013). It is important to remark the actions taken by Global Alliance for Cleaner Cookstoves (GACC) and Energising Development (EnDev). GACC was created in 2010 and focuses its intervention in substituting traditional cookstoves for improved ones. In particular, its objective is to replace 100 million cookstoves by 2020. EnDev promotes sustainable access to modern energy services worldwide. EnDev[4] works in 24 countries improving access to renewable energies, increasing grids or substituting traditional cookstoves for improved ones.

To emphasize the relevance of water and energy services for the poor, note that after the deadline of the MDG's, the United Nations established a new set of goals called Sustainable Development Goals (SDG) with a time horizon of 15 years. Through these Goals, UN wants to achieve both the eradication of poverty and attaining a sustainable development in economic, social and environmental terms. The SDG highlight both the importance of water services and the access to clean energy. Within this Goals, United Nations wants to achieve universal and equitable access to safe and affordable drinking water and access to affordable, reliable, sustainable and modern energy for all the population by 2030.[5]

The objective of this thesis is to analyse the provision of water and energy services in developing countries. It contains two empirical papers focusing in the particular case of Peru. In this sense, it is important to remark that Peru is a country that has benefited from an important growth in last years, but where a large number of communities living in rural areas face severe problems to access safe drinking water and clean energy sources. In the case of water services, piped water coverage is lower than similar countries of the region and in the last years it has been difficult to increase coverage through public or private firms. The regulation of the water sector in Peru has undergone a major change in the last decades. On the one hand, there has been an important decentralization process to give more responsibility to the regional and local municipalities for managing and supervising the provision of the service. On the other hand, the government has established a clear separation in the regulation of the urban and rural areas, and has promoted the participation of rural communities in the expansion and management of water systems. In

[4] It is funded by Australia, Germany, Netherlands, Norway, United Kingdom and Switzerland.

[5] United Nations. https://sustainabledevelopment.un.org/topics

urban areas the service is usually provided by large public firms that are under the responsibility of local and regional authorities and supervised by a sectorial regulatory agency. In the rural communities of less than 2,000 inhabitants the service is usually provided by communal organizations that are called Juntas Administradoras de Servicios de Saneamiento (JASS), which are supervised by local governments.

In 2006 the government of Peru approved the Plan Nacional de Saneamiento 2006-2015, which established various priority actions for rural areas, such as the modernization of the management of the water sector; ensure the sustainability of the infrastructure; improve the quality of the service; and increase the access to improved water. The Plan states that local governments should supervise the JASS and that should be prioritized the rehabilitation of the systems, the training of the JASS members and the health education of the population. It also shows the need to modify the tariff structure in order to guarantee that revenues generated cover the operational and the maintenance costs, and that prices reflect the quality of the service.

In the case of energy, only half the Peruvian population living in rural areas use non-contaminant fuels for cooking purposes. In 2012, the Ministry of Energy and Mines (MINEM) of Peru approved the Plan de Acceso Universal a la Energía 2013-2022 to meet the needs of the most vulnerable population. The objective of this plan is to provide universal access to energy and improve energy efficiency. One of the projects that have been developed in this regard is the Fondo de Inclusión Social Energético (FISE), which is a social energy compensation system for the low income population. The main objective of FISE is the universal access to natural gas for both residential and vehicular uses. In the residential case, the FISE program aims to promote access to LPG (liquefied petroleum gas) to families whose houses are located in the poorest districts. To do so, discount vouchers of 16 nuevos soles (about 5$) are offered to buy an LPG cylinder. The FISE has been applied in the poorest municipalities of Peru, which are identified through a poverty map elaborated by the statistical office of Peru (INEI, Instituto Nacional de Estadística e Informática). In those districts, the voucher is offered to poor households. It is important to note that this program not only promotes the use of LPG but also offers LPG cookstoves to poor households that cannot afford them. Hence, this program is promoting the substitution of traditional cookstoves for cleaner ones.

2 Historical background

At 50s, many economists favoured state ownership of firms in several industries, as monopoly power and externalities produced market failures (Shleifer 1998). This trend eased the rapid growth of the public sector in developing countries during the 60s and 70s decades. In the case of colonial countries this trend was influenced by inheriting a public company at the time of independence.

Despite the ideological trend advocating that public ownership of these companies would improve its efficiency, the growth of the public sector was also motivated to capture rents by governments (Van der Walle, 1989). On the other hand due to the absence of a sufficiently mature private sector that would facilitate the privatization, in some developing countries there was only public provision.

From the 80s it was noted that most of these companies had difficulties to cover costs which in turn caused a burden on the governments of many countries. Furthermore, the services offered by public firms were not meeting the standards that people expected from them, mainly due to service rationing and supply interruptions (Estache, Foster and Wodon, 2002). The low quality of the service and the limited coverage caused the discontent of the population. This situation, coupled with the government fiscal problems, facilitated the privatization of public firms in several countries (Van de Walle, 1989).

In developing countries, reforms in sectors like energy, transportation or telecommunications were more intense in the 90s, and were favoured by technological change. International organizations, like World Bank and the IMF, a number of private transnational banks and governments of some countries promoted these reforms, trying to increase the efficiency of markets (Bierstekker 1990, Ramamurti 1992, Bayliss 2002, Brune et al. 2004). Moreover, privatization was often a requirement to be eligible to get funding through World Bank and the International Monetary Fund (Bayliss 2002). In general, many of the reforms introduced in this period were focused on reducing the role of the state in the economy to rely on market mechanisms. (Bierstekker 1990)

According to World Bank (2001) revenues earned by governments of developing countries due to privatizations in the 90s amounted to more than 300 billion dollars. Moreover, this figure goes up to 1101.6 billion dollars for the period 1985-1999. Although privatization was more common in developed countries, it is important to note that the bulk of transactions were in low and middle income. According to Brune et al. (2004), from a total of 8172 transactions during this period more than a half, 4269 took place in middle income countries. Also the three regions more active were Eastern Europe and Central Asia (2453 transactions), Sub-Saharan Africa (1662) and Latin America and the Caribbean (1601). Moreover, emphasize that the privatization of telecommunications and energy infrastructures were the most active in this period. In addition, the most active region in the 90s was Latin America, where privatizations achieved a revenue of approximately $ 177 billion, equivalent to 56% of the total revenues for all regions during this decade (World Bank 2001).

As privatization was justified by the expected improvement in efficiency caused by the private management of the service, several papers have analysed whether privatization has achieved the goal of improving efficiency and eased access to the service to the population of developing countries. Several studies show that the most important factor that facilitated the improvement of market efficiency in this period was the introduction of effective competition (Martin and Parker 1997, Villalonga 2000, Megginson and Netter 2001, Prizzia, 2001, Shirley and Walsh, 2001, Estache et al., 2012). The technological change favoured the introduction of competition in telecommunications and energy sectors, easing the impact of privatization. On the contrary, these changes have been of minor importance in the water and sanitation sector, which made privatization difficult.

Several studies have analysed the effects of privatization across sectors. McKenzie and Mookherjee (2003) analyse the effects of privatization in various sectors of four Latin American countries (Argentina, Bolivia, Mexico and Nicaragua). They conclude that privatization has facilitated the expansion of the service in water, energy and telecommunications. Devkar et al. (2013), using 67 studies as a basis for their work, found a positive relationship between the privatization of telecommunications, energy and water sectors with the increase in service access and quality. Still, these authors point out that the impact on access to the service is higher in telecommunications than in the other two sectors. This is due to the problems for investing in basic infrastructure in water and energy services but also because private firms had not incentives to expand services through rural areas.

Zhang et al. (2002, 2003) found that the main reasons of the improvement in the energy sector have been the introduction of competition and the creation of an independent regulatory agency. They explain that where liberalization has taken place before privatization and has been accompanied by the creation of an independent regulator it has increased electricity generation, generating capacity and has stimulated an efficient use of capital. This result is justified by Devkar et al. (2013) who sustain that privatization is efficient if it is accompanied by the creation of an independent regulatory body. Regarding coverage, although privatization increases access to the service, by itself does not facilitate the extension of the service to rural areas. Clarke and Wallsten (2002) found that after privatization 47% of urban households in Africa had access to electricity, while only 7% of rural households did. This is because private firms have focused their attention in urban areas, richer than rural ones.

Privatization has not favoured coverage increases in rural areas, especially in Sub-Saharan Africa. Still, it is important to note that in some cases privatization has succeeded to increase coverage of electricity in rural areas, mainly due to external reasons, such as the creation of laws, like in the case of Peru (Alcazar et al. 2008), financing services through cross-subsidies (Tremolet and Neale, 2002), or steams from special government or utility's programs (Clarke et al., 2005).

In water and sanitation the situation is more complex because of the difficulty to generate competition in this sector. Moreover, another important problem to improve access to water services in developing countries is the high cost and technological difficulties to expand the service. In this sense, literature focuses on the impact of privatization on market coverage. High provision costs make entry unattractive to private companies (Devkar et al., 2013). Moreover, in some cases, privatization has led to price increases because the pre-privatization prices were often below costs for social or political reasons (Bakker 2007, Casarin et al. 2007, Marañon 2005). This price increase has caused the disconnection of poor homes, unable to afford the service. This situation has facilitated the expansion of private water vendors in poor neighbourhoods (Bakker 2007). On the contrary, Clarke, Kosec and Wallsten (2009) when analysing the privatization of drinking water in Brazil, Argentina and Bolivia do not find evidence that privatization has hurt the poorest households. In general, the access of poorest households to the service increased or remained constant after privatization. It is remarkable that they found that performance outcomes in cities operated by private and public operators were similar.

To sum up, the economic literature has shown that privatization alone cannot achieve universal access in these services. Taking this into account, in order to achieve the SDG's it is important to know what policies can encourage the expansion of private firms in water and energy sectors to rural areas. Moreover, some rural areas are so poor that neither private nor public firms are willing to invest in basic infrastructures to provide these services. As a response to this situation, in poor rural areas of developing countries it is common the presence of communal organizations for the provision of basic services, like water or education. In this context, it would be important to examine how public policies can improve the performance of communal organizations to ease the expansion of the service in rural areas and achieve universal access.

Another important issue is to develop programs that improve the access of the rural population to clean energies. In this sense, it is important to clarify that rural populations of developing countries have usually very limited economic resources and as a result they normally combine the use of modern fuels, like electricity, with pollutants ones for cooking and heating purposes. In this context, it is essential to analyse how to implement efficient programs to achieve the substitution of traditional cookstoves by cleaner ones, like improved or LPG cookstoves. These programs should devote special attention to low income households because those are the ones that can obtain more benefits from this substitution, and also because they cannot afford the change to clean energies.

Finally, it is important to emphasize the importance of water, sanitation and energy services in the health of the population. In this sense, it is remarkable the study of Wang (2003), which analyses the effects of different variables in the mortality rates. As expected, access to clean water and sanitation has a positive effect on reducing the mortality rate, but a similar effect is found for the access to electricity. Moreover, he shows that access to electricity is an important driver for infant mortality and mortality among children under 5 years. In both cases, regardless of analysing the data at national or disaggregated level between urban and rural areas, access to electricity reduces the mortality rates. The author does not explain the reasons for this result, but it seems that electricity improves the health of household's members because it reduces the consumption of pollutant fuels like firewood, due to heating, cooking or lighting.

3 Regulation and governance of water systems in developing countries

Access to safe drinking water and energy is essential for improving the quality of life and the health of people living in rural areas of developing countries. In 2013 about 5 million deaths were due to diarrhoeal or respiratory problems worldwide. Moreover, these problems are the main causes of death in children under 5 years in developing countries. Annually about one million children under 5 years die from respiratory problems in the world, which is the leading cause of death in this age group. In the case of diarrhoea, between 1990 and 2013 there has been a reduction of 51% in the mortality caused by this disease, but it remains a major cause of mortality in developing countries. More than 600,000 children under 5 years die each year from diarrhoea-related problems around the world. (Global Burden of Disease Study, 2013 and WHO, 2012). Providing access to piped water and sanitation infrastructures can dramatically reduce child mortality (WHO 2002; Kosek, Bern, and Guerant 2003). In this regard it is noteworthy the study of Galiani et al. (2005) where authors find that the privatization of drinking water in Argentina was accompanied by a significant reduction in infant mortality among children under 5 years, especially in the poorest households.

Mortality is not only a problem for children affected by diarrhoea. Literature has shown that there is also a relationship between having suffered diarrhoea in childhood period and morbidity. Past and frequent episodes of severe diarrhoea in childhood affect the normal growth of children and their health conditions (Merrick, 1985; Behrman and Wolfe, 1987; Esrey et al., 1991; Lavy et al., 1996; Lee, Rosenzweig, and Pitt, 1997; Jalan and Ravallion, 2003).

Access to safe water also reduces the incidence of other related diseases, apart from diarrhoea. Esrey et al. (1991) analyse 144 articles where the effects of access to potable water and sanitation services in relation to various diseases are studied. Their conclusion from this literature is that access to these services reduces mortality from diarrhoea by 26%, from trachoma by 27% and 29% by ascariasis, among other diseases.

The conclusions of this literature make evident the need to analyse the policies that are more efficient to expand the coverage of water and energy services. One of the aspects that we analyse in this thesis is the effects of the competition between water utilities and water vendors in developing countries.

The presence of water vendors, water kiosks and standpipes can improve the situation of the poor population living in urban areas served by public firms. But this might reduce the revenues of water firms and as a consequence their ability to expand the water network to rural areas. An adequate regulation of the market is therefore essential to improve the social welfare.

The regulation and supervision of water quality and treatments is also essential for improving health conditions of the population. In this sense, any water policy in developing countries should be coupled together with policies aiming at improving the quality of the service. In addition of extending the infrastructure, it is important to improve the quality of the service to achieve real improvements in population's health.

As mentioned before, communal organizations are an important player in the water sector in rural areas of developing countries. Indeed, communal organizations that take care of the construction, maintenance and operation of water systems have a significant presence in rural areas of Latin American, especially in the Andean countries. Any public strategy for increasing the accessibility of safe water in rural and remote regions needs to consider the role of the communal organizations for the sustainability of the system and for the education of the community members. FANCA (2010) estimated that there are about 77,000 communal organizations throughout Latin America serving more than 40 million people. In this thesis we examine which are the factors that determine the existence of communal water organizations and we also analyse their governance problems.

4 Substitution of traditional cookstoves

Energy deprivation makes it impossible for a society to improve health (GNESD, 2006). The importance of access to energy is verified by the number of developing countries that have adopted policies and set targets for increasing the access to energy services. From 140 developing countries, 68 have set targets for access to electricity, 17 to modern fuels, and 11 to improved cookstoves (Bazilian et al., 2012). In the case of electricity, it is important to highlight the problems arising from the use of polluting fuels as substitutes for modern fuels. Specifically, 1.26 billion people are still without access to electricity and more than twice as many people still use biomass for cooking (Bonjour et al., 2013). It is important to note the use of polluting fuels for cooking. Elias et al. (2005) show that 90% of the energy use of poor households in developing countries is for cooking. Indeed, pollutants emitted by traditional solid fuels in inefficient cookstoves generate indoor air pollution (IAP), which is a major factor of premature deaths (Bruce et al., 2000; Lim et al., 2012; and WHO, 2006a).

Inefficient cook stoves pose serious health threats as biomass combustion inside the household is one of the main factors for indoor air pollution (IAP). Moreover, there is a positive relationship between IAP and ARI symptoms (Dey et al., 2011; Ezzati and Kammen 2001). Also, indoor air pollution has been clearly associated to lung cancer, chronic obstructive pulmonary disease, and pneumonia. In addition, there is emerging evidence of the link between indoor smoke and tuberculosis, low birth weight and perinatal mortality, asthma, cataracts, and cardio vascular diseases (Burki, 2011). This situation is mainly because smoke contains an array of unpleasant chemicals—carbon monoxide, methane, nitrous oxides, benzene, sulphur and arsenic (from coal), and formaldehyde, to name a few. (Burki, 2011). The results of these studies have highlighted the problem of the use of traditional cook stoves, and have boosted the urgency in replacing these stoves by more efficient ones, such as improved or LPG cook stoves.[6]

In recent years, several small projects have been adopted in developing countries to replace traditional stoves for improved ones (Granderson et al., 2009). Moreover, several international organizations such as the public-private partnership Global Alliance for Clean Cookstoves (GACC) are financing programs to promote the use of clean kitchens. GACC and its partners are working to establish a global market for cooking solutions in order to increase the adoption of clean cookstoves. Their approach resumes in three points: enhancing demand for clean stoves and fuels; enhancing the supply of clean stoves and fuels; and fostering the establishment of a market for clean stoves. GACC has focused its attention in 8 countries (called focus countries), Bangladesh, China, Ghana, Guatemala, India, Kenya, Nigeria and Uganda. But it also operates with partner countries that commit to their principles. At present, there are

[6] Laboratory studies have shown that LPG stoves emit no pollution in the home and that ICS reduce the number of pollutants in the home, so these two types of cook stoves are good responses for improving the health of household's member (Singh et al 2012). In spite of this, there are other studies showing that the efficiency of improved stoves reduces over time and at long term the pollution emitted is the same as traditional stoves (Hanna, Duflo and Greenstone, 2012).

43 partners countries in all regions of the World.

The World Bank has also focused its attention on cleaner cookstoves and launched the Africa Clean Cooking Energy Solution Initiative (ACCES). The aim here is to promote enterprise-based, large-scale dissemination and adoption of clean cooking solutions in Sub-Saharan Africa (World Bank, 2012). ACCES seeks to achieve its goal by creating a consultative approach for the cooking sector. It promotes enterprise-based approaches, promotes strategies to make clean fuels and technologies accessible and affordable, promotes efficient biomass stoves up to the final transition to cleaner fuels, integrates gender considerations and aligns with existing country strategies, programs and partnerships.

Finally, EnDev is a multi-donor partnership that promotes sustainable access to modern energy mainly in rural areas of 24 developing countries. EnDev focuses in energy use for household applications, energy for cooking, and energy for small and medium-sized enterprises. The energy services and resources promoted should be reliable, affordable, socially acceptable and good environmentally. EnDev operates in the cooking sector through easing the dissemination of improved cookstoves thanks to self-sustaining markets. It promotes the substitution of traditional stoves for improved ones but also tries to create a market for these cook stoves: it incentives households to become consumers of this type of stoves and local entrepreneurships to become suppliers.

In this thesis we will analyse the FISE Program created in Peru to promote the use of LPG cookstoves. The Peruvian government subsidizes the use of these cookstoves by giving vouchers to low income households. Moreover, government offers LPG cookstoves to poor households that do not have one. This measure contrasts with the initiatives of other countries that subsidize or regulate the price of LPG, benefitting households that could afford the service. Subsidizing the purchase of LPG by poor households is more difficult as it requires identifying correctly the target group and supervise it closely, but might be a more effective measure.

5 Main hypotheses of the thesis

In developing countries water utilities face competition from water vendors and standpipes which provide water to the low income or non-covered population. This situation can alter the investment decisions of the water utilities. In addition, the expansion strategy of water firms can be affected by the regulation of the sector and the structure of the market. In the last 15 years water coverage has increased in rural areas of developing countries from 71.2% to 84.1%, but only 1 out of 3 people living in rural areas rely on piped water.

Chapter II of the thesis proposes a theoretical model to study how the presence of water vendors and the regulation of the market affect the decision of water utilities to expand their coverage in rural areas. Specifically, we want to know how the presence of a fringe of competitive vendors that offer a low-quality service can affect the investment decisions of utilities in rural areas. On the other hand, we want to analyse how the presence of these competitors affects the decision of water utilities to release products of different qualities, such as indoor connections and standpipes. The main hypothesis of this chapter is that water utilities can adjust the quality of their services to moderate the effects that water vendors have in their revenues. This situation might entail a sharp reduction in the quality of standpipes, the low quality technology. In addition, the presence of competitors might reduce the coverage of indoor connections.

As mentioned before, the main objective of the water policy should be to favour the access of all the population to high quality water services. Keeping this in mind, we consider that a correct design of the water regulation should take into account how water utilities strategically respond to the presence of competitors. In this sense, the regulation of prices and the establishment of universal service obligations for the standpipes can modify the incentives of the firm to behave strategically. We also examine the implications of establishing geographically uniform prices for the services.

Finally, this chapter also discusses the results of separating the provision of indoor connections and standpipes through two independent firms. In this case, our hypothesis is that this regulation will incentive firms to increase the quality of their services and will incentive the water utility to expand the coverage of indoor connections.

Chapter III examines the presence of communal water systems in developing countries. As explained before, an important problem to guarantee the universal access to water services is the difficulty to expand water networks to remote and poor villages with high delivery costs and very low-density population. In many occasions, the state has failed to provide basic water services to these areas at minimum quality levels and affordable prices. When this happens, citizens might turn to their communities for the self-provision of the service. The objective of this chapter is to analyse the viability of community managed organizations to deliver public services in the rural areas of developing countries. For this objective, we examine the Juntas Administradoras de Servicios de Saneamiento (JASS), which are communal organizations that provide water services to a large part of the Peruvian population.

Communal water organizations are very prevalent in Latin American countries and in Peru, but our hypothesis is that their creation in a particular community depends on its socio-economic characteristics. We want to examine if the presence of the JASS is related to the cultural characteristics of the community such as the concentration of the ethnic group of Quechuas, the influence of pre-Columbian traditions of communal work, and the language spoken in the community. On the other hand, we want to analyse if JASS represent a cost-effective system to organise the provision of water services. In this sense, our hypothesis is that communal organizations might be able to provide water services with similar quality characteristics (coverage of indoor connections, tariffs, water treatments, etc.) than public systems. Indeed, the JASS might compensate for their lack of financial and technical resources with the volunteer work of their members, their higher incentives to provide safe water, and their higher knowledge of the needs of the community.

Finally, this chapter also discusses the governance problems that face communal organizations and analyses different mechanisms that can be adopted in order to improve their sustainability and accountability.

Chapter IV evaluates the effects of the FISE program introduced in 2012 in Peru with the objective of substituting traditional cook stoves for LPG ones. As mentioned before, increasing the proportion of the population using clean stoves is an essential objective to achieve the 7th goal of the SDG. In this chapter we want to test if the FISE program has been successful in targeting the low income households as beneficiaries, we want also to examine its consequences in the cooking habits of the population. Cooking is one of the most fuel consuming activities in rural areas, and it is important to implement policies that effectively increase the use of clean stoves. On the other hand, we want to examine which have been the effects of the FISE program in the health of the beneficiaries' households. As explained, cooking is one of the main factors for indoor contamination and the substitution of traditional stoves for LPG stoves can moderate health problems of household members.

On the other hand, LPG stoves can also be used to boil the water, and this can reduce the prevalence of water-related diseases.

One regulation that has recently been introduced in some countries consists in subsidizing the price of LPG cylinders, but the effectiveness of this measure has been questioned because it usually benefits high income households that can increase their consumption of this energy at a lower price. In the case of the FISE program, the objective of the Peruvian government has been to directly subsidize low income households that usually have a low consumption of energy. In this regard, FISE program grants them discount vouchers to buy LPG cylinders. Taking this into account, we want to test if this policy has been efficient in order to increase the use of LPG fuel by low income households.

A different question is the impact of the program in the health of the population. Although the program can be efficient in increasing the use of LPG stoves for cooking, this will not necessarily improve the health conditions of the household members. In this sense, it is important to note that the use of LPG cookstoves could be complemented with the use of pollutant solid fuels for cooking or heating purposes. We believe that if families continue using pollutant fuels inside their home the health benefits of the program can be reduced significantly, and this intervention would need to be complemented with other measures.

6 Thesis structure

The thesis consists of three different essays analysing the hypotheses mentioned previously. The main objective is to analyse how different policies and approaches can help governments in developing countries to ease the access to water and energy services in rural areas, to improve the quality of water services, and to substitute polluting traditional stoves for LPG stoves.

Chapter II presents a theoretical model to analyse the investment decision of a water utility facing competition from water vendors. Chapter III describes the presence of communal organizations in Peru, and empirically analyses the factors that explain their creation in rural areas and their performance regarding public water systems. Chapter IV analyses empirically the results of the FISE program in Peru, which was implemented in 2012 to substitute traditional stoves for LPG ones. Specifically, we evaluate its effects in changing the cooking habits of the population and its impact in different health measures.

Finally, Chapter V highlights the main contributions of the thesis.

6.1 The regulation of water provision in developing countries

The objective of Chapter II is to analyse the optimal product line of a regulated water utility facing competition from water vendors and supplying piped water through two types of technologies, indoor connections and standpipes, in urban and rural areas. We use a theoretical model to analyse how different policies can influence the decision of a water utility to expand coverage in rural areas, and to understand how these policies can affect the quality of the service offered by the firm in both areas.

Scarcity of resources makes it very difficult to match the investment and maintenance of urban water systems with the expansion of piped water to rural areas. In developing countries, the proportion of population without access to piped water varies significantly. In Sub-Saharan Africa, the unconnected urban population can be around 80% in Central African Republic, Democratic Republic of the Congo, Guinea-Bissau, Liberia, Madagascar, Nigeria, Rwanda, Sierra Leone and Togo. In Latin America, the unconnected rural population is as high as 40% in some countries like Bolivia, Cuba, Dominican Republic, El Salvador, Nicaragua or Paraguay. Unconnected population usually obtains water from alternative sources that have less quality, such as standpipes, kiosks and water trucks, or through "informal" sources like resellers of piped water, mobile water vendors and small scale independent providers. According to Keener et al. (2010), informal water market can account for as much as one third of overall coverage in some African cities. In many occasions, water resellers are neither prohibited nor legalized. For various reasons, water firms and governments simply don't control their practice.

In the eighties and nineties, the discontent about the quality of basic services and the fiscal difficulties led the Governments of many developing countries to privatize their utilities and to liberalize the markets (Van de Walle, 1989; Chong et al. 2004). As we have explained before, several empirical studies have analysed the effects of the reforms in the coverage and the quality of piped water and its impact in the health of the population. In spite of this, little attention has been devoted to analyse the effects that alternative provision technologies and management systems can make on the population.

Usually water firms expand standpipes and piped networks simultaneously in order to cover the cost of the required investments. But, for example, water authorities could expand standpipes at the expense of household's connections to increase coverage more quickly at lower cost. This measure implies to move the focus of the universalization policies from the individual households to the communities. Mara and Alabaster (2008) suggest the use of standpipes and yard-tap cooperatives served by community managed sanitation blocks and, for non-poor households, in-house multiple-tap cooperatives served by condomial sanitation. It is expected that these technology mix can imply significant cost savings because they require less piped length for the public distribution network.

One of the few papers that has analysed the effect of water management on the quality and the coverage of the service in developing countries is Laffont and N'Gbo (2000). The authors show that in the presence of corruption it might be adequate to cross-subsidize the expansion of the service to the poor areas with the revenues obtained from the richer ones in order to avoid using public funds. In this context, geographical uniform prices reduce coverage, since they eliminate the possibility of setting higher prices in the rich areas to finance cross-subsidies. In a different paper, Laffont et al. (2004) show how a uniform price affects the coverage of the service when there is asymmetric information between regulators and the regulated firms.

In this chapter, the strategy of a regulated water utility that faces the competition of a fringe of competitive vendors is analysed. To do so we use a theoretical model to analyse different policies a regulator can impose to improve social welfare. First, we examine the case were the firm is not forced to serve all the country. Next the analysis focuses on the effects of universal service obligations on the investment decision of the firm. In this case it is considered that the regulator forces the water firm to cover all the country with standpipes while the water firm can decide the coverage of piped water. One important assumption of this model is that the prices of the firm are regulated.

The last part of the essay examines the case where the provision of standpipes is delegated to an alternative provider. Moreover it is also analysed how an imposition of a geographical uniform price for standpipes affects the coverage of piped water.

One of the most interesting results of this chapter is that in the presence of competitors the water utility offers standpipes (low quality technology) in addition to piped water, and that this strategy increases consumers' surplus. Standpipes increase the revenues of the firm and contribute to finance the expansion of the network. In spite of this, when the quality of the product offered by the competitors is too low the utility might choose not to offer standpipes to obtain more revenues from piped water subscribers. This situation favours the expansion of the network, but excludes the low type consumers from the service.

When the regulator forces the water firm to provide standpipes in all the country, consumers living in rural areas are better off, but this reduces the number of piped water subscribers in the urban region. This is because this regulation reduces the profitability of offering the two technologies in some rural villages in comparison with the profits that can be obtained by offering only standpipes. As a result, the utility reduces its coverage.

Finally, the case where the provision of standpipes is delegated to an alternative provider is analysed. The existence of the competitor affects the coverage of the water utility but increases the access to the service by low type consumers. It is shown that the imposition of a geographical uniform price for standpipes could reduce or increase the coverage of the water firm depending on the costs of increasing coverage. When the costs of increasing coverage are low enough, a uniform price for standpipes incentives the water firm to reduce coverage to reduce the competition with standpipes. On the other hand, when costs are high, a uniform price for standpipes incentives the water utility to increase coverage because this strategy reduces competition of standpipes in those villages served with indoor connections.

6.2 Community managed water systems: the case of Peru

Chapter III analyses the factors that determine the presence of communal water systems in the rural areas of Peru, and it compares the performance of these organizations regarding public water systems.

Access to water services is not homogeneous across regions. In rural areas worldwide the rate of access to water is 82.5% but only 66.3% to piped water. In the specific case of Peru, in 2012 only 71.6% of the rural population had access to water and just 62.8% of the rural population had access to piped water.

Some of the problems that make difficult the expansion of piped water services to rural and remote areas are the poverty of the population and the governance problems of local governments. Several policies have been adopted to remedy this situation, including privatization, the liberalization of the market and the use of intermediate solutions such as public-private partnerships, and as we explain later, a number of academic papers have analysed the impact of such policies.

An aspect that has been overlooked in the literature is that in many rural and remote areas, public and private water systems are unsustainable because local governments do not have the financial resources to maintain them and consumers are unable to pay the full cost of the service. Moreover, local communities often oppose to privatization. In these situations, communal provision has emerged as an alternative to provide water services to population groups that would otherwise be unattended.

Communal water organizations are civil associations of users who run the service and often are also responsible for constructing and maintaining the water infrastructures. Usually these organizations work independently of the state, although in recent decades governments in several Latin America countries have regulated them and offered them training and technical support. The importance of the local communities in guaranteeing the sustainability of the water system has been recognized by governments and international organizations alike, and most public plans elaborated in the last years have directly involved the local communities. Quite surprisingly, though, very little is known about the performance of these organizations.

A few papers have studied how to design effective projects for water supply, concluding that demand-responsiveness, community participation and social capital are key to the success of the projects. However, much less attention has been devoted to analysing the factors that favour the creation of communal organizations and their overall performance. Taking this into account, in this chapter we analyse communal water organizations in Peru, which are called Juntas Administrativas de Servicios de Agua y Saneamiento (JASS).

In recent years, several public programs in Peru have financed the construction and rehabilitation of water infrastructures in rural units, and the resulting systems are usually managed by the JASS. Most of the JASS, however, face major difficulties: they lack protocols that guarantee the quality of their services, some of them do not have sufficient resources or technical training to treat the water properly; they lack well established subsidization schemes, and many of their members are unable to pay the water fees. These challenges have led some communities in Peru to create alternative organizations that escape government regulation, and which are managed on private principles. Still, the JASS remain as the main communal water organizations in Peru.

In this chapter we examine communal organizations in Latin America and Peru, with the objective of understanding what are their main characteristics and governance problems. In order to analyse these organizations we use data from the ENDES Survey.[7] This is a detailed survey at the household level elaborated by the Peruvian Statistical Institute. We use the information about water providers, characteristics of the service, variables explaining living conditions, health and socio-demographic characteristics of households between 2006 and 2010. The number of observations is over 50,000. Using this data we estimate an empirical model to analyse the main determinants of the presence of communal organizations providing water. It is shown that one key determinant is the location of a household. Rural households have more possibilities of being provided by a communal organization. Also, the historical roots of communities affect their probability of being served by a communal organization. The longer a municipality was influenced by the Inca Empire, the higher the probability of being served by a communal organization. Finally it is shown that the more homogeneous is the municipality, the higher is the probability of being served by a communal organization.

Moreover, results show that households served by JASS pay lower monthly bills than those served by public firms. The main reasons are that users have lower income but also because they work as volunteers in the construction, operation and maintenance of the systems. It is important to note that lower fees increase access to the service. Another important result is that access to piped water, inside or outside home, is less common for households served by JASS. This is mainly due to the lack of financial resources of JASS. This result explains that JASS users tend to spend more time to collect water. Not surprisingly as some JASS users do not have a connection inside or outside home, as said before. Finally, an important remark is that JASS systems tend to operate without interruptions in comparison with public firms.

[7] Encuesta Demográfica y de Salud Familiar.

6.3 LPG Cook stoves in Peru: Evaluation of the FISE Program

Chapter IV analyses the FISE program in Peru. Among other objectives, FISE is promoting the use of LPG cookstoves by low income households. The main objective here is to evaluate if the program has been successful in increasing the use of LPG cookstoves among the target population. Moreover, it is analysed if the program has improved the health of the household's beneficiaries.

As explained before, a major health problem in developing countries is that pollutants emitted by traditional solid fuels in inefficient stoves generate indoor air pollution (IAP), which is a major factor of premature deaths (Bruce et al.,2000; Lim et al., 2012; and WHO, 2006a). According to WHO (2005), 19% of mortality in infants under 5 years is caused by acute respiratory infections (ARI), which is the second cause of infant mortality worldwide. In Peru, around 6.4 million people do not use modern and clean energy sources to cook. More than 50% of the households in rural areas usually use kerosene, wood or charcoal for cooking. As a consequence, lower respiratory infections are the leading cause of morbidity and mortality in children under 5 years: 2,355 children under age 5 die every year because of these infections, which represents 15.52% of total mortality in children (Global Burden of Disease, 2010).

In Peru, in 2012 the Government created the "Fondo de Inclusión Social Energético (FISE), which aims to promote access to clean energy to the most vulnerable population and reduce energy inequality in the country. One of the main instruments used by FISE consists of the free delivery of LPG cook stoves as well as discount vouchers for buying LPG cylinders. Vouchers substantially reduce the price of LPG and each family can receive at most one voucher monthly. To gain access to these benefits families have to consume less than 30 Kwh of electricity per month and their annual income should be lower than 18,000 nuevos soles.

In order to examine the FISE program we use a database created in 2015 by OSINERGMIN (the Peruvian regulator of the energy sector). This database is mainly based on a survey that was conducted in several municipalities in the Province of Ayacucho. The households interviewed were chosen after stratifying the population taking into account their socio-economic characteristics. The objective was to create a balanced sample where the characteristics of control (households not participating in the FISE program) and treatment (households beneficiaries of the program) are the most similar possible. We apply matching techniques to evaluate the results of the program.

In this chapter, we analyse the effects of the FISE program by comparing several outcome measurements in a group of households' beneficiaries of the program and another group that because of its similar characteristics could have participated in the program but that actually did not. Specifically, the outcomes considered in the empirical model are: the weekly number of meals cooked with LPG stoves; the respiratory problems of the population; the use of kitchens to boil water and children's school attendance. For this objective, we use the information of both users and non-users of LPG cook stoves to estimate a logit model that considers the connection status of households as dependant variable. Then results of this model are used to predict the probability of households to participate in the program. Afterwards, these probabilities are used to identify counterfactual households using different matching algorithms. First, the households in the district that do not participate in the program are stratified into those which are likely to benefit from the program and those which are not. The former are the hypothetically beneficiaries and they are compared to the actual beneficiaries in Ayacucho. In addition, two classical matching methodologies (nearest neighbour and Kernel) are used to further verify the results.

The analysis shows that households with higher incomes are the ones that use clean energy regularly. Specifically, in the richest quartile of the population, 28% of households use clean fuel for heating, while in the poorest quartile the figure drops to 7.5%. On the other hand, we find that as family income increases, the use of fuel wood stoves decreases and the use of LPG stoves increases. Moreover, family incomes also determine the ratio of meals that are cooked with LPG stoves weekly. Among the population with LPG stoves, while the highest income quartile cooks about 75% of the weekly meals with LPG stoves, in the lower one, this ratio drops to 56%. This result shows that poor households combine the use of LPG stoves with traditional stoves, which generate more pollution. This situation justifies the government intervention to subsidize the use of cleaner energies.

The evaluation of the FISE program shows that it has promoted an increase in the use of LPG as cooking fuel. Also, this increase is more important in the lower strata of the population. In spite of that, the program is failing to completely replace traditional stoves for LPG ones. Our analysis does not find a direct link between the reception of the voucher and a reduction of cough or breathing problems in beneficiary households. Moreover, the voucher reception does not seem to reduce the number of days that children miss school due to respiratory problems. A possible explanation for this result is that the households' beneficiaries of the program still use firewood both for cooking some of their meals and for heating. Finally, an interesting result of the chapter is that voucher reception enables the replacement of traditional or improved stoves by LPG stoves for boiling water. One possible explanation for this is that LPG stoves require less time to boil water, and this makes more convenient for households to boil water, which in turn reduces the prevalence of water-related diseases. Indeed, our analysis shows that children in beneficiary households miss fewer schooling days due to diarrhoeal problems. However, most of the findings of this paper should be treated with caution due to the small sample size.

Chapter II: The regulation of water provision in developing countries: coverage, quality and prices[1]

1 Introduction

The relevance of water for human development and for the eradication of poverty was highlighted in the United Nation's Millennium Declaration of 2000 and since then important efforts have been made in many developing countries to increase the access to water services. The main problem is the lack of access to piped water to poor households living in the slum areas of cities and in rural regions. However the scarcity of resources makes it very difficult to combine the maintenance of urban water and sanitation systems with the expansion of piped water to rural areas. This chapter analyses different regulatory interventions that can help to increase the access to water services and the quality of the service when water utilities face the competition of water resellers.

In developing countries, the proportion of population without access to piped water varies significantly. In Sub-Saharan Africa, the unconnected urban population can be around 80% in Central African Republic, Democratic Republic of the Congo, Guinea-Bissau, Liberia, Madagascar, Nigeria, Rwanda, Sierra Leone, Togo, or less than 20% in Botswana or South Africa. In Latin America, the unconnected urban population is lower than 10% in most countries, although the percentage can be higher than 40% in the rural population of some countries like Bolivia, Cuba, Dominican Republic, El Salvador, Nicaragua, Paraguay. Unconnected population usually obtain the water from alternative sources that have less quality, such as standpipes, kiosks and water trucks, or through "informal" sources like resellers of piped water, mobile vendors and small scale independent providers. According to Keener et al. (2010), informal water market can account for as much as one third of overall coverage in some African cities, and for more than this among the unconnected urban population of cities with high up-front cost to connect to the network. In many occasions, water resellers are neither prohibited nor legalized: for various reasons utilities and governments simply don't control their practice.

In the eighties and nineties, the discontent about the quality of basic ser-

[1] Joan Calzada and Alex Sanz

vices and the fiscal difficulties led the Governments of many developing countries to privatize their utilities and to liberalize the markets (Van de Walle, 1989; Chong et al. 2004). These reforms were favoured by the technological change and by the pressures of some international institutions interested in increasing the efficiency of markets (Bierstekker 1990, Ramamurti 1992, Bayliss 2002, Brune et al. 2004). In the water and sanitation services these changes were less important than in other services such as telecommunications or electricity due to the difficulties of creating competition. Several empirical studies have analysed the effects of the reforms in the coverage and the quality of piped water and its impact in the health of the population (Mckenzie and Mookherjee, 2003; Galiani et al., 2005; Wallsten and Kosec, 2008; Gassner, Popov and Pushak, 2008; Galiani et al., 2009; Clarke, Kosec, Wallsten, 2009; Calzada and Iranzo, 2013).

In regard of the welfare effects of privatization over agents, one paper that has analysed these effects is Estache and Grifell-Tatjé (2013). Authors analyse how the welfare generated by the water privatization in Mali was distributed among agents involved. Agents who benefited the most were labor and suppliers of water production and treatments due to an increase in wages and input prices. For labor, two reasons explain this. First, a costly wage structure inherited from the public company. Second, the wages of a minority of workers (specialized technicians from abroad), the board and the CEO.[2] In the case of water production the agent most benefited was the electricity firm due to power consumption,[3] also suppliers of water treatment materials benefited.[4] Consumers had also benefited but in a lower extent due to a reduction in real prices.[5] The more benefited had been residential consumers and the least ones were the public fountain consumers. Finally, as the firm had been incurring in loses,[6] the government had to subsidize the firm. This suggests that taxpayers lost with the privatization. Also, it is remarkable that water supply rose 43% and the firm reduced water losses from 40% to 30%.

[2]The share of labor gains obtained by managers and expatriates equate to a 50% of total labor gains (Gomez-Ibanez, 2005)

[3]Electricity was also supplied by the firm itself and charged at one of the highest rate per kwh in West Africa.

[4]When materials were imported, suppliers were related to the French owner of the firm.

[5]Real prices decreased in the period, a 3% for residential subscribers, 5% for public fountains and 2% for industrial and high consumers.

[6]The firm operated in Bamako and in Outside Centers (secondary towns and cities). While in Bamako operation generated profits, in Outside Centers operation generated losses all over the period.

In spite of this, little attention has been devoted to analyse the effects that alternative provision technologies and management of water networks can make on the population. Thus, for example, water authorities could expand standpipes at the expense of households connections to increase coverage more quickly at lower cost.[7] This measure implies to move the focus of the universalization policies from the individual households to the communities. Mara and Alabaster (2008) suggest the use of standpipes and yard-tap cooperatives served by community managed sanitation blocks and, for non-poor households, in-house multiple-tap cooperatives served by condomial sewage. These systems imply significant cost savings because they require less piped length for the public distribution network.

One of the few papers that has analysed the effect of water management on the quality and the coverage of the service in developing countries is Laffont and N'Gbo (2000). The authors show that in the presence of corruption it might be adequate to cross-subsidize the expansion of the service to the poor areas with the revenues obtained from the richer ones in order to avoid using public funds. In this context, geographical uniform prices reduce coverage, since they eliminate the possibility of setting higher prices in the richer areas to finance cross-subsidies. In a different paper, Laffont et al. (2004) show how a uniform price affects the coverage of the service when there is asymmetric information between the regulators and the regulated firms.

Following Laffont's theories, Estache and Wren-Lewis (2009, 2010) analyse the key problems that face regulation of network industries in developing countries. Among other problems, authors show that limited fiscal efficiency of developing countries joint with the limited ability of consumers to pay for services limited the expansion of state-owned firms. Limited fiscal efficiency not only reduces the expansion of the service but also can cause a trade-off between affordability and access to the service. Price restrictions increase affordability but decrease access. To solve this problem authors recommend the use of cross-subsidies when the marginal cost of public funds is high. In this situation access and affordability are financed through higher prices from richer areas or consumers. On the other hand, when the marginal cost of public funds is low, subsidies are the optimal solution to increase both access and affordability. In addition, problems of limited commitment affect negatively the expansion

[7] Usually utilities expand standpipes and piped networks simultaneously in order to cover the cost of the required investments.

of the service in the long term. Moreover, when governments can not make commitment, the firm has incentives to underinvest (Estache and Wren-Lewis, 2009).

Our chapter contributes to this theoretical literature by analysing the strategy of a regulated utility when it can use different technologies to provide water and faces the competition of water resellers. First, we analyse the strategy of a regulated utility that faces the competition of a fringe of competitive vendors. We show that in the presence of competitors the utility offers standpipes (low quality technologies) in addition to piped water and that this policy increases consumers' surplus. Standpipes increase the revenues of the utility and contribute to finance the expansion of the network. In spite of this, when resellers offer a low quality product, the utility might prefer to eliminate standpipes to obtain more piped water subscribers.[8] This situation favours the expansion of the network, but excludes the low type consumers from the service.

We also consider the case where the water utility is forced to cover all the country with standpipes and decides the coverage of piped water. We show that this regulation increases the consumers' surplus of the population living in the rural areas, but reduces the number of piped water subscribers in the rural region.

The last part of the chapter examines the case where the provision of standpipes is delegated to an alternative provider. We show that the existence of the competitor affects the coverage of the utility but increases the access to the service by low type consumers. We also show that the imposition of a geographical uniform price for standpipes reduces the coverage of the water utility.

Our work is related to the theoretical literature that analyses the impact of the economic regulation in the enhancement of public services in rural and remote areas (Anton et al. 1998, Armstrong 2001,Calzada 2009, Chone et al. 2000, Mirabel et al. 2009, Sorana 2000, Valletti et al. 2002, Estache and Wren-Lewis (2009, 2010)). However, our model is more related with the literature that examines the incentives of a firm to commercialise a service through different channels. Mussa and Rosen (1978) and Moorthy (1984) proved that a monopoly can be interested in offering more than one version of a prod-

[8] Estache and Wren-Lewis (2010) also recommend the diversification of quality as a method to increase affordability. Also, authors show that when regulators have limited capacity, the firm has incentives to reduce quality if it is less likely observed by the regulator.

uct through different channels if the revenues collected for the extra versions are higher than the loss of income due to the cannibalization of the original product. Stokey (1979) and Salant (1989) proved that the commercialisation of more than one version is optimum only when the marginal cost function of improving quality is convex enough. Recently, some papers have analysed the optimality of using several commercialisation channels when the firm faces competition (Anandalingam et al., 2003; Valletti and Szymanski, 2006; and Calzada and Ordoñez, 2013). Nevertheless, these papers don't consider the case where there are increasing costs of expanding the networks or where the retail prices are regulated.

The empirical literature has also studied which is the best market structure to provide the water service in developing countries. There is a recent debate in the literature and in some international institutions on whether investment in water infrastructures should focus on providing safe "shared" drinking water sources, or whether individual access should be prioritized. Devoto et al. (2012) show that many households are willing to pay a substantial amount of money to have a private tap at home. Taking this into account, facilitating access to credit for households to finance lump sum quality-of-life investments can significantly increase welfare, even if those investments do not result in direct income or health gains. Other papers have analysed the effects of water robberies in the profitability of water utilities. Wu et al. (2008) analyse the privatization of the public firm offering water in the metropolitan area of Manila in 1997. The division of the firm in two similar private firms, Maynilad Company (joint venture between Suez and Benpres) and Manila Water Company (joint venture between Ayala, United Utilities and Bechtel) allows the authors to examine the success of MWC in universalizing the service and the failure of Maynilad.[9]

Our chapter continues as follows: Section 2 introduces the basic model. Section 3 presents the case when the water utility provides piped water and standpipes to the same region. Section 4 considers the case where the utility is forced to supply standpipes in all the country and determines the coverage of

[9]Maynilad decided to operate in Manila in a similar way as Suez operates in developed countries and was less attentive in universalizing the service. In the poor areas it installed meters near houses and distant from the central meter, facilitating the theft of the service. As a result, water losses increased significantly. On the contrary, MWC installed meters remote from houses and near from the central meter. This strategy reduced the theft of water from 58% to 35%.

piped water. Section 5 analyses the coverage decision of the utility when the management of standpipes is delegated to another operator. Finally, Section 6 concludes.

2 The model

A water utility can use two technologies to distribute water: it can offer high quality water through indoor connections, H, and low quality water through standpipes, L. We consider that the quality of H is u and that the quality of L is w. Consumers can also buy the water through water resellers, R, which offer an intermediate quality $r \in [w, u]$. In developing countries resellers usually provide a service preferred by consumers over standpipes, though this depends on relative pricing. They are present in cities where the distance between standpipes is too large or the usage too high. Resellers can also be households of the neighborhood that offer more convenient hours of operation, better water pressure or more flexible payment mechanisms that either public standpipes or water utilities (Keener et al. 2010). For simplicity, in what follows we consider that resellers are price takers and that satisfy $p_L < p_R < p_H$.[10]

The utility serves a country where all villages have the same population and where consumers' marginal valuation of quality is θ, which is uniformly distributed in the interval $[0, 1]$. Taking this into account, the net utility of a consumer that buys service $i \in \{H, R, L\}$ is $\theta i - p_i$, where p_i is the price of the service. Finally, we consider that consumers living in areas not covered by any provider, or that can't afford the service, can still seek their own water sources by harvesting rainwater, drilling shallow wells and collecting surface water. We don't model these alternative sources and simply consider that they obtain a net utility equal to zero:

$$\text{Consumer's net utility} = \begin{cases} \theta u - p_H, \text{ if he buys } H \text{ from the utility;} \\ \theta r - p_R, \text{ if he buys } R \text{ from a water reseller;} \\ \theta w - p_L, \text{ if he buys } L \text{ from the utility;} \\ 0, \text{ if he uses an alternative water source.} \end{cases}$$

The segmentation of consumers changes according to the services offered by the utility. When the utility only commercialises H the consumer indifferent

[10] We have also analysed a model where resellers offer the low quality service, obtaining similar conclusions. Results can be obtained from the authors upon request.

between H and R is θ_{HR}, and the consumer indifferent between R and not buying any service is θ_{R0}. On the other hand, when the utility offers both H and L the consumer indifferent between H and R is θ_{HR}, the indifferent between R and L is θ_{RL}, and the indifferent between L and not buying any service is θ_{L0}.

For late reference, we also define consumers' surplus in each village for the case in which the utility offers both H and L and when it only offers H.

$$\text{Consumer's surplus} = \begin{cases} CS_{HR} = \int_{\theta_{HR}}^{1} (\theta u - p_H)d\theta + \int_{\theta_{R0}}^{\theta_{HR}} (\theta r - p_R)d\theta; \\ CS_{HRL} = \int_{\theta_{HRL}}^{1} (\theta u - p_H)d\theta + \int_{\theta_{RL}}^{\theta_{HR}} (\theta r - p_R)d\theta + \int_{\theta_{L0}}^{\theta_{RL}} (\theta w - p_L)d\theta. \end{cases}$$

The profits of the utility depend on the services commercialised, the number of consumers that buy each service and the coverage of its network. We assume that villages are uniformly distributed in the segment $[0, \bar{v}]$, where $\bar{v}$ represents the size of the country. For simplicity, we assume that $\bar{v} = 1$. Villages are ordered according to the cost of providing the service and we assume that the cost of reaching village v is $d\frac{v^2}{2}$. On the other hand, to make the model simple, we assume that the cost of distributing the water is zero for all water sources. Hence, the only costs considered by the utility are those of expanding its network. The profit of the utility is:

$$\text{Utility's profits} = \begin{cases} \pi_{HR} = p_H(1-\theta_{HR})v - d\frac{v^2}{2}, \text{ when it only offers } H. \\ \pi_{HRL} = p_H(1-\theta_{HR}) + p_L(\theta_{RL} - \theta_{L0})v - d\frac{v^2}{2}, \text{ when it offers } H, L \text{ and } r > w. \end{cases} \tag{1}$$

3 Versioning without universal access

This section studies the commercial strategy of the utility when it competes with a group of resellers. The utility might offer only H or it might offer both H and L to better fight resellers and obtain additional consumers. As a benchmark, next we examine the commercial strategy of the utility when it does not have any coverage restriction and the prices are unregulated.

Consider the following timing of the game: First, the utility decides if it commercialises H or both H and L. Second, the utility sets the prices of the services and its coverage level. And third, consumers make their choices and decide which water source to use.

Proposition 1 *The commercial strategy of an unregulated water utility when $r \in [w, u]$ is:*

1) *When $w < r < r_1$ and $r_2 < r < 1$ it offers both H* and *L, and only these services are active.*

2) *When $r_1 < r < r_2$ it offers both H* and *L, and H, L* and *R* are active.

Proof: *See the Appendix.*

The proposition shows that in the presence of resellers the utility always offers L in order to fight R and to protect its profits. Three cases can occur. When $r \in [w, r_1]$ the utility offered by R is so low that nobody buys it (Region A in Figure 1). When $r \in [r_1, r_2]$ the prices set by the utility make some consumers buy R (Region B). In this situation, there is a complete segmentation of consumers: low type consumers use standpipes, intermediate consumers use water resellers and high type consumers use piped water. Finally, when $r \in [r_2, u]$ the prices of H are so low that nobody buys R (Region C). The utility prefers to reduce the price of H if this can be compensated with a higher price of L.We also observe from Figure 1 that with these prices the number of consumers that access the service decreases because the price of L increases.

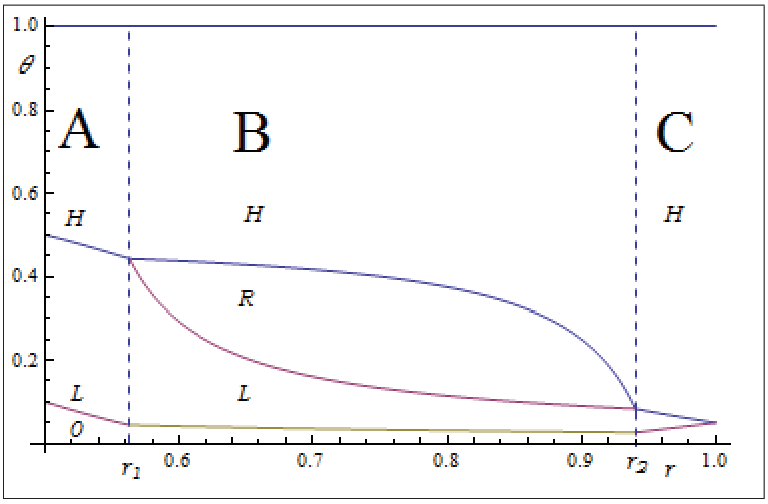

Figure 1. Consumer segmentation with unregulated utility.
$(u = 1,\ w = 0.5,\ p_R = 0.05)$

It is important to highlight that in the three cases described above the presence of resellers allows low type consumers to access the service. First, some intermediate consumers buy from the resellers. And second the utility releases standpipes at a low price, which allow some additional consumers to access the service. By contrast, when the unregulated utility doesn't have any competitor it doesn't supply L and only high type consumers can subscribe to piped water in the served villages.[11]

To sum up, the presence of resellers modifies the commercial strategy of the utility. The utility offers standpipes to maintain part of its revenues and as a result it increases the affordability of the service. In spite of this effect, resellers reduce the profitability of the utility and as a consequence there is a reduction in the coverage. As shown in the proof of Proposition 1, the optimal coverage of the utility for $r \in (r_1, r_2)$ and for $r < r_1$ and $r > r_2$ are, respectively:

$$v_{HRL} = \frac{u - r + p_R[2 + p_R(\frac{1}{u-r} + \frac{w}{r(r-w)})]}{4d} < v_{H0;} \quad (2)$$

$$v_{HL} = \frac{4p_R(r - p_R)u + ((r - 2p_R)^2 - 2ru + u^2)w}{4d(r^2 - 2rw + uw)} < v_{H0;} \quad (2)$$

Calling v_{H0} the coverage of the utility when it only offers H and there are not resellers, it can be seen that the presence of the competitors reduces the coverage of the utility.

Imagine now that the prices of H and L are regulated, but that the managers of the utility still decide the versioning strategy and the coverage. The timing of the new game is as follows. First, the utility decides which services to commercialise. Second, it sets its coverage. Third, the regulator establishes p_H and p_L. And finally, consumers decide which service to buy.

Proposition 2 *The versioning strategy of a regulated water utility is:* [12]

1) *When* $w < r < \overline{r}_1$ *the utility only releases* H, and H and R *are active.*

2) *When* $\overline{r}_1 < r < \overline{r}_2$ *the utility releases both* H and L, *and only these services are active.*

[11] This result has some resemblances to the versioning model of Valletti and Szymanski (2006), who show that a pharmaceutical laboratory is interested in releasing a fighting version when it faces the competition of a generic product. In their model, the fighting version cannibalizes the high quality product, but this is compensated by the additional revenues obtained from the fighting service. In our model, the fighting version reduces the market share of resellers but doesn't affect the high quality product.

[12] For $p_H < p_R + u - r$ and $\frac{p_R w}{p_R + u - p_H} < p_L < \frac{p_R w}{r}$ the versioning strategy could be slightly different. See the appendix.

3) *When* $\overline{r}_2 < r < \overline{r}_3$ *the utility releases both* H and L, *and* H, L and R *are active.*

4) *When* $\overline{r}_3 < r < u$ *the utility only releases* L *and only* L and R *are active.*

Proof: *See the Appendix.*

When the regulator regulates the prices, the utility releases one or two services depending on the quality offered by resellers. When $\overline{r}_3 < r < u$ the quality of the resellers is very high and the utility only finds profitable to offer L at the regulated prices (Region D in Figure 2). When $\overline{r}_2 < r < \overline{r}_3$ the utility releases both H and L and some consumers buy R because its relative price is not too high (Region C). When $\overline{r}_1 < r < \overline{r}_2$ the utility offers the two services but now the consumer's utility from buying R is so low that nobody buys it at the regulated prices (Region B). In this interval, if the utility only offers H some consumers buy R because it is cheaper. If it offers both H and L it obtains less revenues from H but this is more than compensated with L. Moreover, nobody buys R. Finally, when $w < r < \overline{r}_1$ the utility only offers H because the release of L would generate less revenues than those that are lost with the cannibalization of H (Region A). An alternative interpretation of this case would be to assume that the utility degrades the quality of standpipes in order to increase its profits.

The main result from this proposition is that price regulation changes the versioning strategy of the utility and the segmentation of consumers. In region A the utility eliminates L in order to increase the number of subscribers to H. But this situation has the paradoxical effect of reducing the number of low type consumers that are able to access the service. This result does not occur for $r > \overline{r}_1$ because in this case the utility always releases L to fight against R. Indeed, in this case, the relevant consumer is not θ_{HR} but θ_{HL}, which is smaller. Also note that $\frac{d\overline{r}_1}{dp_H} < 0$, which implies that an increase of the regulated price reduces the likelihood that the utility only offers H. This result is relevant for the regulatory policy in the sector because it shows that, when the quality of R is close to the quality of L, a reduction of p_H can incentive the utility to degrade the quality of standpipes or to eliminate them in order to obtain more profits.

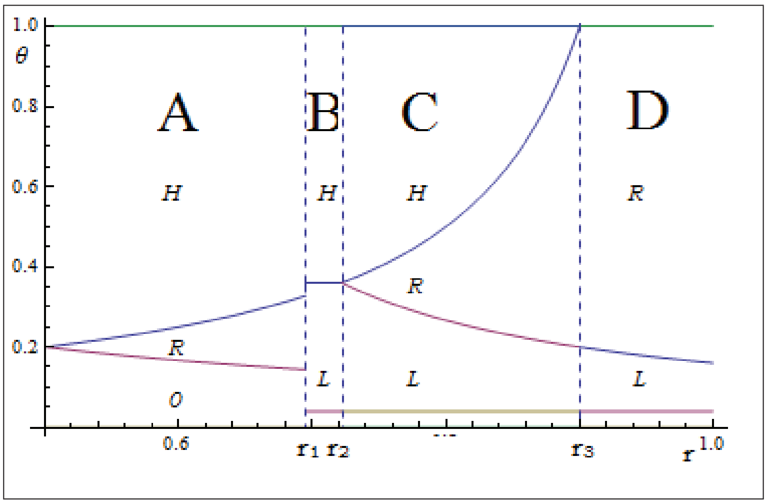

Figure 2. Consumers' segmentation with price regulation.
($u = 1$, $w = 0.5$, $p_r = 0.1$, $p_H = 0.2$, $p_L = 0.02$)

The versioning strategy of the regulated utility also determines its coverage level. The next result shows the coverage levels for the intervals defined above.

Corollary 1 *The coverage offered by a regulated water utility is:*

1) *When* $w < r < \overline{r}_1$ *and the coverage is* $v_{HR} = \frac{p_H(r-u-p_R+p_H)}{d(r-u)}$;

2) When $\overline{r}_1 < r < \overline{r}_2$ *the coverage is* $v_{HL} = \frac{p_L(2p_H w - p_L u) - p_H w(p_H - u - w)}{d(u-w)w}$;

3) When $\overline{r}_2 < r < \overline{r}_3$ *the coverage is:* $v_{HRL} = \frac{1}{d}\left(\frac{p_H(p_R - p_H - r + u)}{r-u} + \frac{p_L(p_L r - p_R w)}{(r-w)w}\right)$;

4) When $\overline{r}_3 < r < u$ *the utility only exist if it offers* L.

Proof: *See the Appendix.*

Figure 3 shows the coverage, aggregated consumers' surplus, and the profits of the utility as a function of r when the prices of the utility are regulated. It is shown that the coverage is higher for $r < \overline{r}_1$ than for $\overline{r}_1 < r < \overline{r}_2$, because for low values of r the utility doesn't realease L and it has more consumers that subscribe to H and pay a high price. As a consequence, the utility serves a larger number of villages. For $r < \overline{r}_1$ the aggregate consumers' surplus decreases with r because the increase of subscribers that use H or R in the marginal villages doesn't compensate the reduction of consumers that can access to the service in the covered villages. On the other hand, for $r > \overline{r}_2$ coverage and consumers' surplus also decrease with r. In this region, the number of subscribers that use R increases with r and as a consequence there are less and less consumers that buy H or L from the utility. In spite of this, the reduction of coverage of the utility is so important that compensates the increase in the consumers' surplus that obtain the users of the reseller.

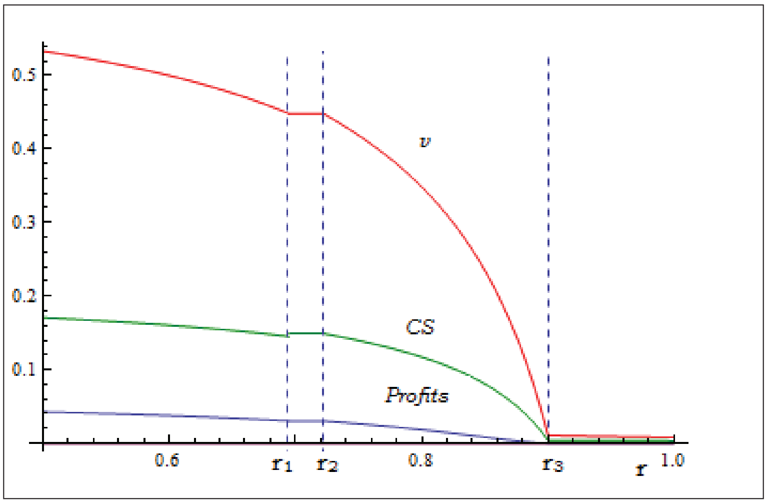

Figure 3. Equilibrium results for a regulated utility.
(u = *1*, w = *0.5*, p_r= *0.1*, p_H= *0.2*, p_L= *0.02*)

4 Versioning with universal access

The previous section has analysed the case of an utility that installs in each village piped water and standpipes. However, in developing countries utilities usually restrict the provision of piped water to urban areas and provide standpipes or yard taps in a larger number of villages. In order to analyse the implications of this situation, we next examine the case where the utility is forced to supply L in all the country and can decide over the coverage of H. Moreover, we allow the utility to set different prices for L in the villages covered by the two services (urban area) and in the villages covered only with L (rural area). Specifically, the profit function of the utility can now be written as follows:

$$\pi = [p_H(1-\theta_{HR}) + p_L^U(\theta_{RL} - \theta_{L0}^U)]v + p_L^R(1-\theta_{L0}^R)](1-v) - d\frac{v^2}{2}, \quad (3)$$

where the indifferent consumers are the same than in the previous section, but now θ_{L0}^U is the indifferent consumer between buying L and not buying in the urban villages, and θ_{L0}^R is the indifferent consumer between L and not buying in the rural villages. Observe that in equation (3) the cost of expanding the network only refers to the cost of deploying the piped water. On the other hand, we assume that resellers are present only in the urban areas. As before, we start the analysis by considering the case of an unregulated utility. The timing of the game is the same than in Proposition 1.

Proposition 3. *Imagine an unregulated utility that provides L in all the country. The utility offers H and L in $v \in [0, v^*]$ and only L in $v \in [v^*, \overline{v}]$, where $v^* = \hat{v}_{HL} = \frac{(u-v)(4p_R r - 4p_R^2 + (u-2r)w)}{4d(r^2-2rw+uw)}$ for $r < r_1$ and $v^* = \hat{v}_{HRL} = \frac{2p_R - r + u - w - p_R^2(\frac{1}{r-u} + \frac{w}{r^2-rw})}{4d}$ for $r > r_1$.*

Proof: *See the Appendix.*

In the urban villages $[0, v^*]$ the unregulated utility sets the prices of H and L as in Proposition 1, $p_H = \frac{p_R - r + u}{2}$ and $p_L^U = \frac{p_R w}{2r}$. This occurs because the segmentation of consumers doesn't depend on the coverage. On the other hand, in the rural villages $[v^*, \overline{v}]$ the utility sets the monopoly price for L, $p_L^R = \frac{w}{2}$, because in this area it doesn't face the competition of resellers. In the proof of this proposition we also show that the coverage of H decreases when the utility is forced to offer L in all the country. Indeed, $\hat{v}_{HL} < v_{HL}$ and $\hat{v}_{HRL} < v_{HRL}$, where v_{HL} and v_{HRL} are defined like in equation (2). With universal access of L the utility only expands the piped network if this generates more profits than just selling L. As L is present in all villages, the utility covers a smaller part of the country than when it is completely unregulated, because now the profitability of expanding the network is smaller.

This result reveals a trade-off between the objective of universalizing the access to L and the expansion of H. When the utility is forced to offer a low quality service to the whole population it reduces the coverage of piped water in peri-urban areas.

Imagine now that the regulator sets the prices of H and L and that the managers of the utility maintain the control over the coverage of H. We assume that the regulator can set different prices for L in the urban and the rural villages to make this situation comparable with those of Proposition 3. In particular, we consider that $p_L^R = t\ p_L^U$, where $t \geq 0$. The timing of the game is the same than in Proposition 2.

Proposition 4. *Imagine a regulated utility that provides L in all the country and decides the coverage of H. The utility offers H and L in $v \in [0, v_{HRL}]$ and only L in $v \in [v_{HRL}, \overline{v}]$, where*

$$\bar{v}_{HRL} = \frac{1}{d}[p_H + tp_L^U + \frac{p_H(p_H - p_R)}{r-u} - \frac{p_L^U(p_L^U - p_R)}{r-w} - \frac{p_L^{U2}(1-t^2)}{w}].$$

Proof: *See the Appendix.*

The regulation of p_H reduces the profits of the utility in the urban villages and as a result it reduces the coverage of H. Indeed, it can be verified that $\frac{d\bar{v}_{HRL}}{dp_H} > 0$ and that $\bar{v}_{HRL}$ reaches a maximum for the monopoly price $p_H = \frac{(u+p_L^U-r)}{2}$. Although the reduction of p_H attracts to the utility some consumers that before were consuming R, this effect is not enough to compensate the loss of revenues.

It is also immediate to see that the coverage of H increases with p_L^U, because this makes urban villages more profitable. But the coverage is determined by the relative prices of L in the urban and the rural villages. Notice that $\frac{d\bar{v}_{HRL}}{dt} < 0$ for $t < \frac{w}{2p_L}$. This implies that the utility chooses the maximum coverage when the regulator sets a price equal to zero in rural areas, i.e. when $t = 0$. Moreover, with this price $\bar{v}_{HRL} = \hat{v}_{HRL}$. This is because with this price, the marginal village covered with piped water is the one that has zero profits, and this village is the same than in the case where the utility was not forced to serve all country with standpipes. Also, with uniform prices, that is when $t = 1$, rural villages are less profitable for the utility and it prefers to expand H. By contrast, when $t = \frac{w}{2p_L} > 1$ the regulator sets the monopoly price in the rural villages, $p_L^R = tp_L^U = \frac{w}{2}$. In this case, the utility is less interested in expanding its piped network because it obtains more revenues with L. Figure

4 shows the coverage, consumer surplus, and the profits of the utility as a function of t when the prices of the utility are regulated.

Finally, the following corollary shows that when the utility is regulated the coverage of H can be higher than without regulation. This occurs when p_H is not too low and the relative prices of L in the urban and the rural villages are not too different.

Corollary 2. $\bar{v}_{HRL} > \hat{v}_{HRL}$ *for* $t < \bar{t}$.

Proof: *See the Appendix.*

To sum up, our previous analysis has shown the effects of regulation in the commercial strategy of the utility. Price regulation can improve social welfare and the situation of some consumers, but it can reduce the access to piped water to some consumers in the peri-urban areas. The reduction in the price of piped water increases the number of users that consume this service in the urban villages and reduces the purchases to resellers. In spite of this, this regulation reduces the coverage of piped water if the price of standpipes in the urban villages is much lower than in the rural villages.

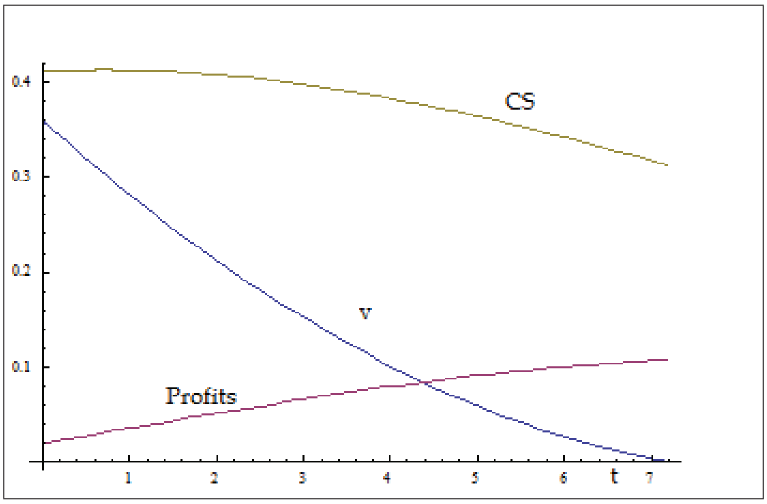

Figure 4. Equilibrium results for a regulated utility.
($u = 1$, $w = 0.45$, $r = 0.65$, $p_r = 0.1$, $p_H = 0.35$, $p_L = 0.025$)

5 Separated management

The previous sections have analysed the case where the water utility manages and supplies piped networks and standpipes. In spite of this, nowadays there is an important debate in developing countries on how public standpipes should be managed. Recent studies conclude that in many cities standpipes are dysfunctional and are poorly maintained. This reduces the number of standpipes in use as well as its quality. Taking this into account, alternative management systems have been suggested (Keener et al., 2010). One possibility is to delegate the operation of standpipes to other operators or water agencies. In this section we analyse the coverage decision of an utility that competes with another firm that manages standpipes in all the country. Therefore, the main change in our model regarding the previous sections is that now each firm only offers one service and that the prices of indoor connections and standpipes are set independently.

Consider first the case of an unregulated utility that offers H and that has a cost $d\frac{v^2}{2}$ for expanding its network. The utility competes against another unregulated firm that offers L and covers all the country. Hence, the two firms compete in a group of urban villages and there is an incumbent firm that is a monopoly in the high-cost rural villages.

The utility obtained by the consumers depends on their location and on the services they consume:

$$\text{Consumer's net utility} = \begin{cases} \theta u - p_H^U \text{ if he buys } H \text{ in the urban region} \\ \theta w - p_L^U \text{ if he buys } L \text{ in the urban region} \\ \theta w - p_L^R \text{ if he buys } L \text{ in the rural region} \\ 0 \text{ if he uses an alternative water source} \end{cases}$$

Next we present the results of the competition when the incumbent sets different prices in the urban and rural villages, $p_L^U < p_L^R$ (price discrimination) and when it sets the same price $p_L^U = p_L^R$ (uniform price) throughout the country. We analyse the following game in three stages. First, the utility determines its coverage. Second, the two firms set their prices. And third, consumers choose their preferred service.

Proposition 5 *The prices and the coverage of H when firms are unregulated are:*

i) With price discrimination: $p_H^U = 2u(\frac{\kappa-1}{\kappa-4})$; $p_L^U = \kappa u(\frac{\kappa-1}{\kappa-4})$; $p_L^R = \frac{\kappa u}{2}$;

$v^d = \frac{4u}{d}(\frac{1-\kappa}{(4-\kappa)^2})$.

ii) With uniform prices: $p_H^U = \frac{(1-\kappa)u(2+\kappa(v-1))}{4+\kappa(3v-4)}$; $p_L = \frac{(\kappa-1)\kappa u(v-2)}{4+\kappa(3v-4)}$; $v^u \lesseqgtr v^d$; where $\kappa = \frac{u}{w}$

Proof: *See the Appendix.*

The first part of the proposition shows the results with price discrimination. In urban villages the differentiation of the products ($\kappa = w/u$) increases the prices of H, but it has an ambiguous effect on the price of L. Moreover, prices are independent of the coverage level of H. In rural villages, the incumbent sets the monopoly price for L, since it doesn't face any competitor. Finally, the coverage of H also depends on product differentiation. Specifically, $\frac{dv^d}{d\kappa} < 0$, which implies that a reduction in the differentiation reduces the profitability of H and as a consequence the utility reduces its coverage. In the proof of the proposition we also show that v^d is higher than the coverage that would choose the utility if it could commercialise both H and L**.** Therefore, competition reduces prices, increases the access to the service, and increases the coverage of H.

The second part of the proposition presents the equilibrium outcomes when the incumbent sets a uniform price for L. As before, the prices depend on the level of product differentiation (κ). Specifically, the increase of product differentiation increases the prices. In this case, however, the prices of the two firms depend on the coverage of H. In the proof of the proposition we show that $\frac{dp_H}{dv^u} < 0$ and that $\frac{dp_L}{dv^u} = 2\frac{dp_H}{dv^u} < 0$. This occurs because the expansion of the duopoly area forces the incumbent to reduce its price more aggressively, which alllows it to attract a larger group of consumers in urban villages. Indeed, when $v^u = 0$ the incumbent is a monopoly in all the country and as a result it sets the monopoly price, but when $0 < v^u < 1$ its price is lower than the monopoly price but higher than the competitive price. The existence of the uniform price changes the indifferent consumers between H and L in each village. In the proof of the proposition we show that $\frac{d\theta_{HL}}{dv^u} > 0$ and $\frac{d\theta_{L0}}{dv^u} < 0$, meaning that the expansion of v when there is a uniform price increases the number of consumers buying L because some consumers that before were consuming H now shift to L and some low type consumers that before were not consuming now buy L.

Finally, it is interesting to mention that the establishment of a uniform price for L affects the coverage of H. Figure 5 compares the equilibrium results with price discrimination and uniform prices. The coverage of H is higher with uniform prices of L if d is high enough. By contrast, it is smaller for low values of d. When d is large the two firms compete in a few villages, so the imposition of a uniform price forces the incumbent to increase the price of L and to set it closer to the monopoly price. This situation incentives a significant group of consumers to shift from L to H, increasing the profits of the utility and its coverage. On the contrary, when d is low, the firms compete in a high number of villages, so the imposition of a uniform price forces the incumbent to set a price close to the competition price in the duopoly area. As a result, the profits of the utility are smaller in the urban villages and it chooses a smaller coverage.

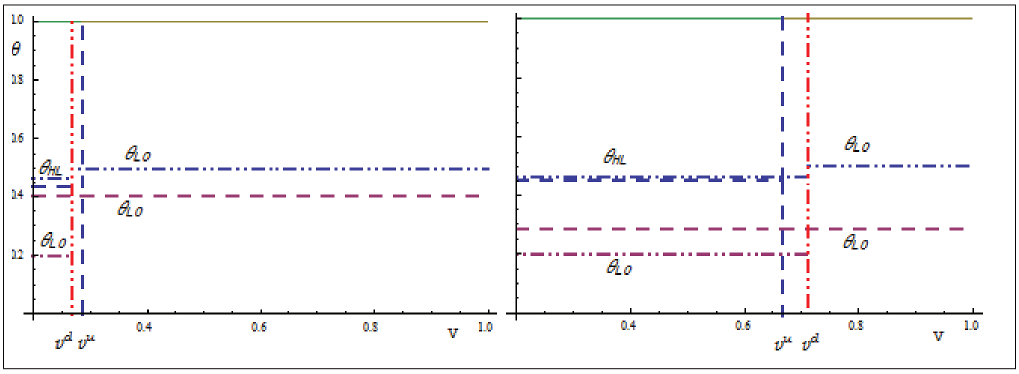

Figure 5. Utility's coverage with uniform price or price discrimination. $(u = 1,\ w = 0.25,\ d = 0.8, d = 0.3)$

Imagine now the case where the prices of H and L are regulated, and the regulator can set different prices for L in the urban and the rural villages. In this context, we want to analyse the coverage decision of the utility when there is price discrimination for L. The timing of the game is as follows. First, the utility decides its coverage level. Second, the regulator establishes the prices of H and L. And finally, consumers make their choices.

Proposition 6 *The coverage level of H when the firms are regulated is:*
$v^r = \frac{p_H^U(-p_L^U + p_H^U + (\kappa - 1)u)}{du(\kappa - 1)}$
Proof: *See the Appendix.*

As before, the coverage of the utility depends on the level of product differentiation (κ). The larger the differentiation, the greater the coverage is. It is also interesting to examine how the regulation of prices affects the coverage. If the regulator sets a low price for L in the urban area this policy decreases the number of consumers buying H, and as a result the utility serves less villages. On the contrary, if the regulator sets a high price for L, there is a number of consumers that change from L to H, increasing the profits of the utility. This facilitates the expansion of the piped water network. Taking this in account, we can compare the coverage of H with and without regulation.

Corollary 2. $v^r > v^d$ *for* $p_L^U > p_H^U + u(1-\kappa)[\frac{4u(1+\kappa)}{p_H^U(\kappa-4)^2} - 1]$

6 Conclusion

The objective of the chapter has been to analyse the provision of water in developing countries when the service can be offered through different technologies. First we have seen that the presence of water resellers forces the utility to offer standpipes in order to retain some consumers. This strategy increases the number of consumers with access to the service and the profits in each village, providing incentives to the utility to increase its coverage. The existence of water resellers facilitates the access to the service in the villages served, although reduces the coverage of the utility.

We have also shown that forcing the utility to serve all the country with a basic service reduces the profitability of piped water and also its coverage. This implies that the obligation of delivering safe water to all the population causes a trade-off between the number of villages with access to piped water and the number of households with access to the basic service in each village. In spite of this, an adequate regulation of the prices of piped water and standpipes can moderate this situation.

The regulation of prices can create winners and losers. When the regulator reduces the price of piped water the utility can reduce its coverage. As a result, subscribers to piped water pay less for the service, but a larger group of consumers are left without a connection. By contrast, when the regulator complements lower prices of piped water with a reduction of the price of standpipes in the rural areas the utility has incentives to expand the coverage of its network. This occurs because the reduction of the price of standpipes reduces the revenues of the utility in rural villages, and as a consequence it is more profitable to expand the piped network.

This chapter has also analysed the situation where the utility offers piped water in a part of the country and the management of standpipes is delegated to an independent firm. We show that this market structure reduces the profits of the utility and, in consequence, its coverage. However, competition increases the number of consumers with access to piped water in the villages covered by the utility. We have also shown that this effect on coverage could be mitigated, or even reverted, by forcing the competitor to fix a uniform price.

The results of this research can be useful for guiding the water policy in developing countries, where there is an important presence of water resellers and where an important part of the population can't afford the access to piped water. In order to increase access to water services, regulatory authorities could impose the installation of standpipes in peri-urban areas and in some rural areas. We have demonstrated that this policy allows consumers in high-cost areas to get access to the service, although it reduces the number of villages covered with piped water. To compensate this situation, prices can be regulated to increase the profitability of piped water. Finally, we have shown that the separation of the management of piped water and standpipes reduces the coverage of the utility but increases the proportion of consumers with access to the service in all villages. Moreover, we have found that setting a low uniform price for standpipes throughout the country, when the costs of expanding the network are high enough, can increase the coverage of piped water.

7 Appendix

Proof of Proposition 1. Consider first the case where the utility only offers H. The indifferent consumer between buying H and R is $\theta_{HR} = \frac{p_H - p_R}{u-r}$ and the indifferent consumer between buying R and not buying is $\theta_{R0} = \frac{p_R}{r}$. Taking this into account, the utility sets p_H and v to maximize $\pi_{HR} = p_H(1-\theta_{HR})v - d\frac{v^2}{2}$. Solving the firm's problem yields:

$$p_H = \frac{p_R - r + u}{2}; \quad v_{HR} = \frac{(p_R - r + u)^2}{4d(u-r)}; \quad \pi_{HR} = \frac{(p_R - r + u)^4}{32d(r-u)^2}. \tag{4}$$

With these results we find that $\theta_{HR} = \frac{p_R + r - u}{2(r-u)}$ and $\theta_{R0} = \frac{p_R}{r}$. Notice that

$\theta_{HR} > \theta_{R0}$ for $r > \widehat{r} = \frac{1}{2}(p_R + u - (p_R^2 - 6p_R u + u^2)^{1/2})$. For simplicity we assume that this condition is always satisfied.

Consider now the case where the utility offers both H and L. In this case, the indifferent consumer between H and R is $\theta_{HR} = \frac{p_H - p_R}{u-r}$, the indifferent consumer between R and L is $\theta_{RL} = \frac{p_R - p_L}{r-w}$, and the indifferent consumer between L and not buying is $\theta_{L0} = \frac{p_L}{w}$. The utility sets the prices p_H, p_L and the coverage level v to maximize $\pi_{HRL} = [p_H(1-\theta_{HR}) + p_L(\theta_{RL} - \theta_{L0})]v - d\frac{v^2}{2}$ and this gives:

$$\begin{aligned} p_H &= \frac{p_R - r + u}{2}; \quad p_L = \frac{p_R w}{2r}; \\ v_{HRL} &= \frac{2p_R r(u-r)(r-w) + r(r-u)^2(r-w) + p_R^2(r^2 - 2rw + uw)}{4dr(u-r)(r-w)}; \end{aligned}$$

$$\pi_{HRL} = \frac{(2p_R r(u-r)(r-w) + r(r-u)^2(r-w) + p_R^2(r^2 - 2rw + uw))^2}{32dr^2(r-u)^2(r-w)^2}. \tag{5}$$

Now, the indifferent consumer satisfies that $\theta_{HR} = \frac{p_R + r - u}{2(r-u)} \geq \theta_{RL} = \frac{p_R(1-\frac{w}{2r})}{(r-w)} \geq \theta_{L0} = \frac{p_R}{2r}$ for $r \in [r_1, r_2]$, where $\theta_{HR} > \theta_{L0}$ for $r > r_1$ and $r < r_2$. We don't show the values of r_1 and r_2 for simplicity. For $r < r_1$ and $r > r_2$ the utility sets $p_L = \frac{p_H r - p_R u + p_R w - p_H w}{r-u}$ in order to guarantee that $\theta_{HR} = \theta_{RL}$. Taking this into account, we get:

$$p_H = \frac{2p_R r(u-w) + (r-u)^2 w}{2(r^2 - 2rw + uw)}; \quad p_L = \frac{w(r^2 + 2p_R(u-w) + uw - r(u+w)}{2(r^2 - 2rw + uw)};$$

$$\begin{aligned} v_{HL} &= \frac{4p_R(r-p_R)u + ((r-2p_R)^2 - 2ru + u^2)w}{4d(r^2 - 2rw + uw)}; \\ \pi_{HL} &= \frac{(4p_R(r-p_R)u + ((r-2p_R)^2 - 2ru + u^2)w)^2}{32d(r^2 - 2rw + uw)^2}. \end{aligned}$$

With these results, we can now examine the optimal versioning strategy of the utility. For $r \in [w, r_1]$ and $r \in [r_{2,}1]$ the utility can offer H and L and obtain π_{HL}, or it can offer H and get π_{HR}. It can be verified that $\pi_{HL} > \pi_{HR}$ for $p_R < r < u$ and $r > w > 0$.

For $r \in [r_1, r_2]$ the utility can offer the two services and obtain π_{HRL} or only H and obtain π_{HR}. In this case, we obtain that $\pi_{HR} > \pi_{HLR}$ when $p_R^2 w(2r^2(p_R - r + u) + (4p_R r(r-u) - 2r(r-u)^2 + p_R^2(u-3r))w) > 0$, which it is only possible for $w > u$, which contradicts our assumptions. Therefore the utility always offers both H and L. **QED**

Proof of Proposition 2. Imagine that the regulated utility only offers H. In this case, the indifferent consumer between H and R is $\theta_{HR} = \frac{p_H - p_R}{u-r}$ and the indifferent consumer between R and not buying is $\theta_{R0} = \frac{p_R}{r}$. Taking this into account, the utility sets v to maximize $\pi_{HR} = p_H(1-\theta_{HR})v - d\frac{v^2}{2}$. Solving this problem yields:

$$v_{HR} = \frac{p_H(r - u - p_R + p_H)}{d(r-u)}; \quad \pi_{HR} = \frac{p_H^2(p_R - p_H - r + u)^2}{2d(r-u)^2}. \tag{6}$$

Next, consider the case where the utility releases both H and L. The indifferent consumer between H and R is $\theta_{HR} = \frac{p_H - p_R}{u-r}$, the indifferent consumer between R and L is $\theta_{RL} = \frac{p_R - p_L}{r-w}$, and the indifferent consumer between L and not buying is $\theta_{L0} = \frac{p_L}{w}$. The utility sets v to maximize $\pi_{HRL} = [p_H(1-\theta_{HR}) + p_L(\theta_{RL} - \theta_{L0})]v - d\frac{v^2}{2}$ and obtains:

$$v_{HRL} = \frac{1}{d}\left(\frac{p_H(p_R - p_H - r + u)}{u-r} + \frac{p_L(p_L r - p_R w)}{(r-w)w}\right);$$
$$\pi_{HRL} = \frac{(p_L^2 r(r-u) + p_R p_L(u-r)w + p_H(p_H - p_R + r - u)w(w-r))^2}{2d(r-u)^2(r-w)^2w^2}. \tag{7}$$

With regulated prices, we find that $1 \geq \theta_{HR} \geq \theta_{RL} \geq \theta_{L0}$ for $r \in [\overline{r}_2, \overline{r}_3]$ when $p_H > p_R + u - r$ or when $p_H \leq p_R + u - r$ and $p_L < \frac{p_R w}{p_R + u - p_H}$. Otherwise, we find that $1 \geq \theta_{HR} \geq \theta_{RL} \geq \theta_{L0}$ for $r \in [\overline{r}_2, \overline{r}_5]$, and for $r > \overline{r}_5$, nobody buys L. By contrast, $\theta_{RL} < \theta_{L0}$ for $r < \overline{r}_2$ and $\theta_{HR} \geq 1$ for $r > \overline{r}_3$. When $r < \overline{r}_2$ nobody buys R and the consumer that is indifferent between H and L is $\theta_{HL} = \frac{p_H - p_L}{u-w}$. In this case, the utility sets v to maximize $\pi_{HL} = [p_H(1-\theta_{HL}) + p_L(\theta_{HL} - \theta_{L0})]v - d\frac{v^2}{2}$. This yields:

$$v_{HL} = \frac{{p_L}^2 u - 2p_H p_L w + p_H w(p_H - u + w)}{d(w-u)w};$$

$$\pi_{HL} = \frac{({p_L}^2 u - 2p_H p_L w + p_H w(p_H - u + w))^2}{2d(u-w)^2 w^2}. \tag{8}$$

On the other hand, for $r > \overline{r}_3$ no consumer subscribes to H. As a consequence, the utility maximizes the following profit function $\pi_{RL} = [p_L(\theta_{HL} - \theta_{L0})]v - d\frac{v^2}{2}$ and gets:

$$v_{RL} = \frac{p_L(p_L r - p_R + w)}{d(r-w)w}; \;\; \pi_{RL} = \frac{p_L^2(p_L r - p_R w)^2}{2d(r-w)^2 w^2}. \tag{9}$$

Taking into account these results, we can establish the versioning policy of the utility. For $r \in [w, \overline{r}_2]$ the firm can offer H and L and obtain π_{HRL} or H and obtain π_{HR}. Considering that $\frac{p_L}{p_H} = t$ it can be shown that $\pi_{HRL0} - \pi_{HR} < 0$ when $r < \overline{r}_1$

$$\overline{r}_1 = \frac{p_R(u-w)w + p_H(w - tu)^2}{p_H(t^2 u + w - 2tw)}. \tag{10}$$

For $r \in [\overline{r}_2, \overline{r}_3]$ the utility offers the two services when $\pi_{HLR} - \pi_{HR} > 0$, which occurs when $p_L < \frac{p_R w}{r}$. However, this is always necessary in order to guarantee that $\theta_{RL} \geq \theta_{L0}$.

Finally, when $p_H < p_R + u - r$ or when $p_H \geq p_R + u - r$ and $\frac{p_R w}{p_R + u - p_H} < p_L < \frac{p_R w}{r}$,we find that $1 \geq \theta_{HR} \geq \theta_{RL} \geq \theta_{L0}$ for $r \in [\overline{r}_2, \overline{r}_5]$. For $[\overline{r}_5, \overline{r}_3]$, as $\theta_{RL} < \theta_{L0}$, no consumer buys L but the firm offers H so only H and R are active. On the contrary, for $r > \overline{r}_3$ the optimal decision of the utility is not to serve the market neither with H or L.**QED**

Proof of Corollary 1.

The coverage that appears in the corollary is straightforward obtained from Proposition 2. On the other hand it can be shown that $v_{HRL} - v_{HR} > 0$, if, and only if, $p_L < \frac{p_R w}{r}$. Moreover, when nobody buys R the coverage is higher when the utility only offers the high-quality service as $v_{HL} - v_{HR} < 0$ for all values of p_H and p_L.

Finally, when the utility only offers the low-quality service its coverage depends on the prices. Indeed $v_{RL} \geq 0$ for $p_L \geq \frac{p_R - w}{r}$.

Proof of Proposition 3. The utility offers throughout the country L, and H and L to a group of low-cost locations (urban villages). In urban villages, when it offers H and L the indifferent consumer between H and R

is $\theta^U_{HR} = \frac{p^U_H - p_R}{u-r}$, the indifferent consumer between R and L is $\theta^U_{RL} = \frac{p_R - p^U_L}{r-w}$, and the indifferent consumer between L and not buying is $\theta^U_{L0} = \frac{p^U_L}{w}$. On the other hand, in the rural villages where it only offers L, the indifferent consumer between L and not buying is $\theta^R_{L0} = \frac{p^R_L}{w}$. Taking this into account, the utility sets p_H, p^U_L, and p^R_L and the coverage v that maximizes $\pi_{HRL} = [p^U_H(1-\theta^U_{HR}) + p^U_L(\theta^U_{RL} - \theta^U_{L0})]v + p^R_L(1-\theta^R_{L0})(1-v) - d\frac{v^2}{2}$. Solving the problem we obtain:

$$\begin{aligned} p^U_H &= \frac{p_R - r + u}{2}; \quad p^U_L = \frac{p_R w}{2r}; \quad p^R_L = \frac{w}{2}; \\ \hat{v}_{HRL} &= \frac{2p_R - r + u - w - p^2_R(\frac{1}{r-u} + \frac{w}{r^2 - rw})}{4d} \end{aligned}$$

And as a result, the profits of the utility are:

$$\pi_{HRL} = \frac{1}{4}(w + \frac{(-2p_R r(r-u)(r-w) + r(r-u)(r-w)(r-u+w) + p^2_R(r^2 - 2rw + uw))^2}{8dr^2(r-u)^2(r-w)^2} \tag{11}$$

As in Proposition 1, with these prices the indifferent consumer in the urban villages satisfies $\theta^U_{HR} \geq \theta^U_{RL} \geq \theta^U_{L0}$ for $r \in [r_1, r_2]$. For $r < r_1$ and $r > r_2$ the utility sets $p_L = \frac{p_H r - p_R u + p_R w - p_H w}{r-u}$ to ensure that $\theta_{HR} = \theta_{RL}$. As a result, only H and L are active and we get:

$$\hat{v}_{HL} = \frac{(u-w)(4p_R r - 4p^2_R + (u-2r)w)}{4d(r^2 - 2rw + uw)}.$$

Finally, we compare the coverage levels of the utility when L is offered in all the country and when it is offered in the same villages that H. Consider v_{HRL} and v_{HL}as determined in Proposition 1. For $r \in [r_1, r_2]$ we get that $v_2 - v_1 = \frac{w}{4d} > 0$. On the other hand, for $r < r_1$ and $r > r_2$ we observe that $\widehat{v}_2 - \widehat{v}_1 = \frac{w}{4d} > 0$.**QED**

Proof of Proposition 4. The regulator sets p_H, p^U_L, and $p^R_L = tp^U_L$ and the utility sets v. When the utility offers H and L the indifferent consumers are the same as in Proposition 3. Taking this into account, the utility sets v to maximize $\pi_{HRL} = [p^U_H(1-\theta^U_{HR}) + p^U_L(\theta^U_{RL} - \theta^U_{L0})]v + p^R_L(1-\theta^R_{L0})(1-v) - d\frac{v^2}{2}$. Solving the problem yields:

$$\bar{v}_{HRL} = \frac{1}{d}(p_H^U - tp_L^U + \frac{p_H^U(p_H^U - p_R)}{r-u} - \frac{p_L(p_L - p_R)}{r-w} + \frac{p_L^2(t^2-1)}{w}) \qquad (12)$$

Moreover, the profits of the utility are:

$${}_{HRL} = \frac{2tp_L^U w(w - tp_L^U)}{2w^2} + \frac{(p_H^U(p_H^U - p_R + r - u)(r-w)w + p_L^U(r-u)w(p_R + t(w-r)) + p_L^2(r-u)(r(t^2-1) - t^2 w))^2}{2w^2(d(r-u)^2(r-w)^2)} \qquad (13)$$

Proof of Corollary 2. Observe that $\bar{v}_{HRL} - \hat{v}_{HRL} > 0$ for $t < \widehat{t}$. We do not show $\widehat{t}$ because it is a long expression.**QED**

Proof of Proposition 5. When the utility offers H in the low-cost urban villages and the incumbent offers L in all the country we can identify two types of indifferent consumers. In the urban villages, the indifferent consumer between H and L is $\theta_{HL}^U = \frac{p_H^U - p_L^U}{u-w}$ and the indifferent consumer between L and not buying is $\theta_{L0}^U = \frac{p_L^U}{w}$. In the rural villages the incumbent has the monopoly and the indifferent consumer between L and not buying is $\theta_{L0}^R = \frac{p_L^R}{x}$. The profit functions of the firms when the incumbent can price discriminate are:

$\pi_I = [p_L^U(\theta_{HL}^U - \theta_{L0}^U)]v + p_L^R(1 - \theta_{L0}^R)(1-v);$

$\pi_U = [p_H^U(1 - \theta_{HL}^U)]v - d\frac{v^2}{2}.$

Taking this into account, we first examine how firms set prices in the second stage of the game:

$$p_H^U = 2u(\frac{\kappa - 1}{\kappa - 4});\ p_L^U = \kappa u(\frac{\kappa-1}{\kappa-4});\ p_L^R = \frac{\kappa u}{2}, \qquad (14)$$

where we have used that $\kappa = w/u$. Replacing in the profit function we get:

$$\pi_U = \frac{4uv(1-\kappa)}{(\kappa-4)^2} - \frac{dv^2}{2}; \quad \pi_I = \frac{\kappa u}{4}(1 - \frac{(12 + (\kappa-4)\kappa)v}{(\kappa-4)^2} \qquad (15)$$

Moreover, with the above prices the indifferent consumers are : $\theta_{HL}^U = 1 - \frac{2}{4-\kappa}$; $\theta_{L0}^U = 1 - \frac{3}{4-\kappa}$;and $\theta_{L0}^R = \frac{1}{2}$.

Finally, in the first stage of the game the utility decides its coverage. Differentiating the profit function in (15) with respect to v we obtain that the optimal coverage is:

$$v^d = \frac{4u(1-\kappa)}{d(\kappa-4)^2} \tag{16}$$

We can compare v^d with the coverage that would set the utility if it could provide the two services. When the firm operates in all the country offering the high-quality service in the urban area and the low-quality service in the rural area, the coverage set by the utility is $\overline{v} = \frac{u-w}{4d}$. If we compare this coverage with the one that the company would establish with competition we see that $v - \overline{v} = \frac{(u-w)[w(8u-w)]}{4d(w-4u)^2} > 0$.

Consider next the case where the incumbent is forced to set a uniform price in the urban and the rural villages. In this case, in the urban villages the indifferent consumer between H and L is $\theta^U_{HL} = \frac{p^U_H - p_L}{u-w}$, and the indifferent consumer between L and not buying is $\theta^U_{L0} = \frac{p_L}{w}$. In the rural villages the indifferent consumer between L and not buying is $\theta^R_{L0} = \frac{p_L}{w}$. Keeping this in mind, firms choose p_H and p_L and v to maximize their profits.

$\pi_I = [p_L(\theta^U_{HL} - \theta^U_{L0})]v + p_L(1-\theta^R_{L0})(1-v);$

$\pi_U = [p^U_H(1-\theta^U_{HL})]v - d\frac{v^2}{2}$

Solving the second stage of the game we find the following results:

$$p_H = \frac{(\kappa-1)u(2+\kappa(v-1))}{4+\kappa(3v-4)};\ p_L = \frac{\kappa u(\kappa-1)(v-2)}{4+\kappa(3v-4)}. \tag{17}$$

$$\pi_I = \frac{(v-2)^2(u-w)w(u+(v-1)w)}{(4u+(3v-4)w)^2}. \tag{18}$$

$$\pi_U = \frac{v(8u^2(u-2dv) + 8u(u(v-2) + d(4-3v)v)w + (2u(v-5)(v-1) - d(4-3v)^2v)w^2 - 2(v-1)^2w^3)}{2(4u+(3v-4)w)^2} \tag{19}$$

Moreover, with the above prices indifferent consumers are $\theta^U_{HL} = \frac{2+\kappa(2v-3)}{4+\kappa(3v-4)}$; $\theta^U_{L0} = \theta^R_{L0} = \frac{(\kappa-1)(v-2)}{4+\kappa(3v-4)}$.

From this we also obtain the following results:

$$\frac{\delta\theta_{HL}}{\delta v} = \frac{\kappa(2+\kappa)}{(4+\kappa(3v-4))^2} > 0;\quad \frac{\delta\theta_{L0}}{\delta v} = \frac{2(\kappa-1)(\kappa+2)}{(4+\kappa(3v-4))^2} < 0$$

This occurs because with a uniform price, the decrease of the incumbent's price generated by the increase of v is twice as high as those of the utility.[13]

Finally, in the first stage of the game the utility sets its coverage. From the profit function in (19) we find that the FOC of profit with respect to v. Specifically v is a root that satisfies:

$$dv(4+\kappa(3v-4)^3-(1-\kappa)u(2+\kappa(v-1))[8+6\kappa(v-2)+\kappa^2(4+3(v-3)v)]=0.$$

QED

Proof of Proposition 6 When the prices of the utility and the incumbent are regulated and there is price discrimination for L we have the following indifferent consumers: in the urban villages, the indifferent consumer between H and L is $\theta^U_{HL} = \frac{p^U_H - p^U_L}{u-w}$ and the indifferent between L and not buying is $\theta^U_{L0} = \frac{p^U_L}{w}$. In the rural villages the indifferent consumer between L and not buying is $\theta^R_{L0} = \frac{p^R_L}{w}$. The profit functions of the firms are:
$\pi_I = [p^U_L(\theta^U_{HL} - \theta^U_{L0})]v + p^R_L(1-\theta^R_{L0})(1-v);$
$\pi_U = [p^U_H(1-\theta^U_{HL})]v - d\frac{v^2}{2}.$

From the profit of the utility we obtain that the optimal coverage is:

$$v^r = \frac{p^U_H(-p^U_L + p^U_H + (\kappa-1)u)}{d(\kappa-1)u} \tag{20}$$

Finally , we can compare this expression with the coverage of the unregulated case when there is price discrimination, we get $v^r - v^d = \frac{p^U_H(p^U_H - p^U_L + (\kappa-1)u)}{du(\kappa-1)} - \frac{4u(1-\kappa)}{d(\kappa-4)^2}$. This expression is positive if $p^U_L > p^U_H + u(1-\kappa)[\frac{4u(1+\kappa)}{p^U_H(\kappa-4)^2} - 1]$

Moreover we can show that product differentiation affects the coverage, as $\frac{dv^r}{d\kappa} = \frac{p^U_H(p^U_H - p^U_L)}{d(\kappa-1)^2u} > 0$.**QED**

[13]Partial derivatives of prices respect to the coverage level are:

$$\frac{\delta p_H}{\delta v} = \frac{(\kappa-1)\kappa(2+\kappa)u}{(4+\kappa(3v-4))^2} < 0; \quad \frac{\delta p_L}{\delta v} = \frac{2(\kappa-1)\kappa(2+\kappa)u}{(4+\kappa(3v-4))^2} < 0.$$

Chapter III: Community managed water systems: the case of Peru[1]

1 Introduction

The economic literature has traditionally considered the state to be responsible for the provision, directly or through other actors, of public services. It can obtain the resources needed to finance the services and has the coercive power to enforce the regulation. Moreover, it is considered that the provision of public services gives legitimacy to the state. Yet, in many developing countries the state has failed to deliver basic services such as water or energy at minimum quality levels and affordable prices. When this happens, the citizens might turn to their communities for the self-delivery of these services (Alesina and Zhuravskaya, 2011; and Lee et al., 2014). The community managed water systems which are prevalent in rural areas of many Latin American countries are a good example of this. In this chapter we focus on Peru and the so-called Juntas Administradoras de Servicios de Saneamiento (JASS), a type of communal organizations that provides water services to more than 3 million people in rural and peri-urban communities of Peru.

The relevance of water for human development and the reduction of water related diseases was highlighted in the United Nation's Millennium Declaration of 2000 and since then, most developing countries have made an important effort to increase the access to drinking water. While in 2000, 17.5% of the world population did not have access to safe drinking water, in 2012 this percentage had been reduced to 10.6%. In Latin America and the Caribbean, access to drinking water increased from around 85.3% in 1990 to 94.2% in 2012 -see Table 1. Moreover, the percentage of the population that has access to piped water increased from 72.3% to 88.2%. In fact, the region reached the Millennium coverage target five years earlier than planned.[2] That said, access to water services is not homogeneous across regions. In rural areas the rate of access to water is 82.5% and to piped water only 66.3%. In the specific case of Peru, in 2012 only 71.6% of the rural population had access to water and just 62.8% of the rural population had access to piped water.

[1] Joan Calzada, Susana Iranzo and Alex Sanz

[2] http://www.un.org/millenniumgoals/

Table 1. Water coverage (in %) in Latin America, 2012.

Country:	National		Rural areas	
	Improved water	Piped water	Improved water	Piped water
Argentina	98.7	98.6	95.3	94
Bolivia	88.1	83	71.9	57.3
Brazil	97.5	92.1	85.3	66.6
Chile	98.8	98.8	91.3	91.3
Colombia	91.2	87.3	73.6	66.4
Costa Rica	96.6	95.9	90.9	88.9
Cuba	94	76.7	87.3	57.6
Dominican Republic	80.9	66.5	77.2	50
Ecuador	86.4	85	75.2	72.3
El Salvador	90.1	73.1	81	49.4
Guatemala	93.8	85.6	88.6	72.7
Haiti	62.4	8.7	47.5	4.2
Honduras	89.6	88	81.5	78.5
Mexico	94.9	90.9	90.8	76.6
Nicaragua	85	63.5	67.8	28.8
Panama	94.3	92.1	86.6	81.1
Paraguay	93.8	77.7	83.4	57.1
Peru	86.8	81.9	71.6	62.8
Puerto Rico*	93.6	86.8	93.6	86.8*
Uruguay	99.5	99.5	94.9	94.9
Venezuela**	92.9	86.8	75.3	51.6
Latin America and Caribbean	94.2	88.2	82.5	66.3

Notes: (*) Year 2011 (**) Year 2007

Source: Joint Monitoring Programme for Water Supply and Sanitation.

Some of the difficulties that impede the increase in the coverage of water services in rural areas are the poverty of the population and the inefficiency of the public systems. Several strategies have been pursued to remedy this situation, including privatization, the liberalization of the market and the use of intermediate solutions such as public-private partnerships, and a number of academic papers have analysed the impact of such policies.[3] However, an aspect that has been overlooked in the literature is that in many rural and remote areas public and private water systems are unsustainable because local governments do not have the financial resources to maintain them and consumers are unable to pay the full cost of the service. Moreover, local communities often oppose to privatization. In these situations, communal provision has emerged as an alternative to provide water services to population groups that would otherwise be unattended.

Communal water organizations are civil associations of users who run the service and often are also responsible for constructing and maintaining the water infrastructures. Usually these organizations work independently of the

[3]For example, the effect on the expansion of piped water and the fees paid by users have been analysed in McKenzie and Mookherjee (2003), Wallsten and Kosec (2008), Gassner et al (2008), Clarke et al (2009) and Tan (2012) whereas Galiani et al (2005), Galiani et al. (2009) or Kosec (2014) had examined the effects on health outcomes.

state, although in recent decades governments in several Latin America countries have regulated them and offered them training and technical support. The importance of the local communities in guaranteeing the sustainability of the water system has been recognized by governments and international organizations alike, and most public plans elaborated in the last years have directly involved the local communities. Quite surprisingly, though, very little is known about the performance of these organizations.[4] A few papers have studied how to design effective projects for water supply, concluding that demand-responsiveness, community participation and social capital are key to the success of the projects. However, much less attention has been devoted to analysing the factors that favour the creation of communal organizations and their overall performance. Focusing on the Peruvian experience, in this chapter we shed some light on these issues.

The structure of the chapter is as follows. Section 2 reviews the literature on community managed projects and the delivery of public services. Section 3 discusses the importance of water communal organizations in Latin America while Section 4 focuses specifically on Peru. The main reforms underwent in the water sector in Peru and the current organization of the sector are described in subsection 4.1. Subsection 4.2 provides a detailed discussion on the Juntas Administradoras de Servicios de Saneamiento (JASS) including an analysis of the factors associated to their presence and their performance in comparison with the public systems. Subsection 4.3 discusses some of the most recent policies that have been adopted to complement the work of the JASS and improve the water service in rural areas. Finally, Section 5 concludes.

2 Theoretical background: communal organizations and the delivery of collective services

One reason for the reduced access to drinking water in developing countries is the inefficiency of state-owned infrastructure monopolies that typically result in budget deficits. Faced with this problem, in the 1990s many countries introduced different types of private service participation (PSP) in the management

[4] An exception is Calzada and Iranzo (2015) that analyses the effect of communal water provision on child health in Peru.

of the water service. This policy received the support of the World Bank and donor agencies, which advocated for the privatization of deteriorated utilities in order to promote investments and service coverage, and to reduce the financial burden on government budgets (World Bank, 1995; Kirkpatrick et al., 2006). The analysis of those reforms yields ambiguous conclusions. While the proponents of private service participation point out that it has improved performance through increased efficiency and cost recovery, allowing for additional financial resources and larger coverage rates among poor consumers, its opponents argue that it has raised the cost of capital, reduced long-term investments in infrastructure, increased corruption and increased prices (Bakker et al. 2008).

The debate is also reflected in the empirical literature that compares the performance of public and private operators. For instance, Estache and Rossi (2002) do not find evidence of superior performance of privately-owned water utilities in Asian countries. Kirkpatrick et al. (2006) analyse a number of firms in African countries and do not find a significant effect of privatization on the cost of the service, although they show that private provision is associated with much higher average water charges and more water metering. Hailu et al. (2012) investigate the impact of water privatization in Bolivia comparing cities where the service was privatized with cities where the system was managed by a cooperative. They find that private concessions failed to meet the targets stipulated in the contracts because expanding the service to the poorest areas was unprofitable. Moreover, the increase in fees led to public outrage that forced the government to renationalize the firms. Tan (2012) argues that the poor results of privatization in terms of network coverage and efficiency might be due to the natural monopoly nature of the water service that often requires subsidizing the fees, and the high risk of infrastructure investment due to high sunk costs, long gestation periods and uncertain revenues. By contrast, other papers show some positive results of privatization. For example, Crampes and Estache (1996) and Galiani et al. (2002) find that privatization led to benefits in terms of the population provided with safe water and sanitation, and Galiani et al. (2005) show large improvements in terms of water quality and reduced child mortality in poor areas after the privatization process in Argentina in the 1990s.[5]

[5] The impact of privatization on child health has also been studied in other papers. Galiani et al. (2008) assess the effects of a program of expansion of the water network undertaken

Another strand of economics literature stresses the importance of involving local communities in the operation of public services and infrastructures. It is believed that community-driven development (CDD) projects and decentralization can overcome some of the difficulties to manage the provision of public services such as schools, water services, and roads in certain areas of developing countries.[6] First, the local communities have a superior knowledge of the actual needs and they also have higher incentives to provide the service at some quality standards. Second, community members are more willing to financially contribute to the projects when they have some level of decision-making. Consistent with this idea, the 1990s witnessed the flourishing of community-managed rural water systems supported by various international agencies. A number of papers have partially examined the results of this model, although they have not explicitly compared community-managed systems to public systems. For instance, Katz and Sara (1997) show that the performance of the service is associated with the level of participation of the community in the design and management of the projects. They also argue that community members are more willing to meet investment costs when they have control over the funds. Galiani et al. (2009) examine a program launched in 2002 by the private firm Aguas de Argentina, together with the local governments and the regulatory agency, to extend water facilities to urban shantytowns. They argue that the success of the program was largely due to the involvement of the beneficiary communities. Bakerlian and Wakeman (2009) and Whittington et al. (2009) analyse the performance of community-managed rural water supply programs in 400 rural communities in Bolivia, Ghana and Peru. They find that the projects operated by communal organizations were performing remarkably well after their construction; most of the private taps were working several years after their creation, consumers were using the system and they were largely satisfied. Spaling et al. (2014) examine the factors that affect the sustainability of community water supply projects in Kenya. They explain how managers try to gain the support of community members by setting personal meetings and sharing information and feedback. Mark et al. (2014) analyse the sustainability of handpumps in 200 rural communities located in two regions of Ghana. They argue that water systems for which more planning meetings

by the private firm Aguas Argentinas. Kosec (2014) studies the impact of privatization on child health for a group of African countries.

[6] See, among others, Besley and Coate (2003), Mansuri and Rao (2004), Estache (2004), Bardhan and Mookherjee (2005) or Casey et al. (2012).

with community members had been held during the construction period were more likely to collect sufficient user fees to cover the maintenance costs. Moreover, project outcomes were better within communities where a larger share of households reported participating in management related decisions. So to sum up, there is consensus in the literature that the participation of local communities is key to guarantee the success and sustainability of projects aimed at delivering collective services.

3 Communal water organizations in Latin America

Communal water organizations have an important presence in rural areas of Latin America. It has been estimated that more than 77,000 of such organizations provide water to around 40 million people. They are particularly prevalent in the Andean countries where the tradition of communal work traces back to the ancient culture of cooperation of the pre-Columbian Maya and Inca civilizations.[7] For instance, in Ecuador there are around 7,000 Juntas Comunales and Juntas de Administración de Agua Potable serving 2,7 million people, the 20% of the total population (PROTOS-CEDIR, 2011). In Colombia, in the 2000s several public programs promoted the creation of Juntas Administradoras, Juntas de Acción Comunal and Asociaciones de Usuarios and nowadays there are about 16,000 communal organizations (Aquavitae 2010; Smits et al. 2012). In Venezuela, in 2002 the government created the Mesas Técnicas de Agua, and in 2007 there were about 2,500 Mesas which participate in the organization, supervision and control of the service and serve more than 900,000 people in rural and indigenous communities (Matos et al. 2008). In rural and peri-urban areas of Bolivia, there are around 4,500 Comités de Agua Potable y Saneamiento (CAPyS), in which local communities own the infrastructures and each household participates in the operation and maintenance of the service (PROTOS-CEDIR, 2011). In Peru, there are more than 5,000 active Juntas Administradoras de los Servicios de Saneamiento (JASS) and other users associations that provide the service to around 30% of the total population (PROTOS-CEDIR, 2011 and Cornejo, 2012).

In many cases, these organizations are the result of government projects

[7] The Maya word for this type of cooperative work is kuchuj and the Inca word is minka.

that sought the support of local communities to expand water facilities and improve service quality in the 1990s. In effect, during those years the general opinion of water specialists was that water systems in rural areas were performing very poorly (Bakalian and Wakeman, 2009); systems were not being repaired, revenues were insufficient to pay for the operation and maintenance costs, communities did not have a sense of ownership of their infrastructures and households were not satisfied with the service. In this context, a consensus emerged among international donors and national authorities that rural water supply programs should incorporate elements of the demand-driven community management models (Sara and Katz, 1997 and Whittington et al. 1998). Communal water organizations are also the default type of provision in areas where, due to economic and technical difficulties, the state fails to provide the service, even though in many countries the government typically regulates their activities and monitors the quality of water. Moreover, communal organizations need to be legally recognized in order to receive funds and technical assistance (FANCA, 2006). Yet, the relation between the communal organizations and the state differs importantly across countries. While in some countries they have considerable autonomy and do not receive any institutional support (e.g., Guatemala or El Salvador) in others they are very dependent of the state (Costa Rica).

The legal structure of the communal organizations is quite similar across countries. Their members are simultaneously owners of the water infrastructure and users of the service. Each household is considered a user and typically one family member participates in the assembly. The decision making tends to follow a vertical structure: the assembly democratically chooses the management board and supervises its activities. Then the management board defines the projects, plans the activities and supervises the provision of water services. The members of the communal organizations contribute with their work to the construction and maintenance of the facilities and can also undertake administrative activities.[8] Some organizations also hire personnel to perform administrative or specialized activities, but this depends on the size and resources of the community. The fees of the service are usually set by the assembly, and only in some countries they are approved by a regulatory authority (e.g. Costa Rica). This leads to different types of governance problems.

[8]For example, in Ecuador the monthly water fee is calculated taking into account the number of days (mingas) worked for the organization.

For example, many communities set the prices too low and/or there is a high percentage of users that do not pay for the service, which results in difficulties to finance the infrastructures and might call for extra payments from the users. Other management constraints faced by the communal organizations include the lack of property rights over the water sources or the land containing the water sources, the high electricity costs to pump the water, inadequate treatment of the water and lack of training of the personnel running the service. Notwithstanding these problems, in the last years the communal organizations have made important progress to improve their governance. Many of them take part in national and international associations with the objective of coordinating their activities. Among other things, these associations purchase untreated water, chemicals and equipment, distribute technical guides or provide training and legal advice. For instance, in Colombia associations like AQUACOL and AMAC have been quite successful in increasing the quality of the water (Smits et al. 2012); in Bolivia, associations like ASICA SUR (in the region of Cochabamba) buy water to the municipal water firm and deliver it in bulk to the communal organizations.[9] Some organizations have also coordinated among themselves to manage the hydric resources of their geographical region or to act as lobby groups vis-a-vis the local or regional authorities.

4 The case of Peru

4.1 Regulatory changes and current organization of the water sector

In line with the reforms undertaken across Latin American countries, in the last decades the water sector in Peru has undergone a number of regulatory changes that have shaped its current organization. The first important set of reforms took place in the early 1990s when the government of Alberto Fujimori initiated the decentralization of the management of water systems. Several subsidiaries and operational units of the state-owned firm SENAPA (Servicio Nacional de Abastecimiento de Agua Potable y Alcantarillado) were transferred to the regional and local authorities.[10] In 1993, local governments were

[9] National associations are also important in Honduras (AHJASA), El Salvador (ANDAR), Costa Rica (ASADAS), and exist in countries like Guatemala, Panama or Peru.

[10] Decreto legislativo No 574 y No 601

made responsible for managing and regulating the water and sewerage systems,[11] and in 1994 the government approved a new law for the sector, Ley General de Servicios de Saneamiento (LGS),[12] which defined the new roles of all firms and participating institutions in the sector and created a national regulator called Superintendencia Nacional de Servicios de Saneamiento (SUNASS). The regulator was initially in charge of supervising the investment plans and the operation of the service across the country, assessing the performance of the operators and approving the fees, but in later reforms its mission was restricted to the supervision of the public firms in urban areas. The government also created new institutions to finance the investments and launched investment projects such as the Programa Nacional de Agua Potable (PRONAP) whose objective was to expand the coverage of the service.[13]

The LGS succeeded in improving the efficiency of urban water operators. It transformed 44 large municipal firms into societies called Entidades Prestadoras de Servicios (EPS). Today these firms belong to the provinces or the municipalities and manage the water and sewerage services in the urban areas of the municipalities. The only exception is the Lima's operator, SEDAPAL, that remained under the control of the central government. The LGS also established that in each municipality the administrative sub-units called population units with less than 2,000 inhabitants (that is, the population units classified as rural)[14] the service had to be operated by JASS (Juntas Administradoras de Servicios de Saneamiento).[15] The JASS were expected to also set the prices and maintain the infrastructures. However, at the time these legislative changes had little effect, especially in rural areas, because they were not enforced (Castillo, 2001). Another problem regarding the water investments made in rural areas in the 1990s was that the projects were not designed in accordance to the actual needs and views of the affected population and the local

[11] Ley Orgánica de Municipalidades. Ley No 27972.

[12] Ley General de Servicios de Saneamiento (No. 26338) of 1994 and the Reglamento D.S. 24-94-PRES.

[13] See Tamayo et al. (2000) for a detailed analysis of this period.

[14] Peruvian municipalities are divided in smaller administrative units called population units (centros poblados). According to a criteria of size and geographical dispersion these units are classified as rural or urban. In particular, the Plan National de Saneamiento 2006-2015 defines rural units as those with less than 2,000 inhabitants and which are not the capital of the municipality. There are 734 urban units that concentrate around the 70% of the Peruvian population (496 units have between 2,001 and 10,000 inhabitants) and 85,138 rural units that concentrate the rest of the population (about 8 million inhabitants).

[15] Before that, the responsibility of providing the service in the rural areas belonged to the Health Ministery (MINSA).

authorities. Moreover, they did not take into account that the new equipment would have to be operated and maintained by the local communities. Some infrastructures were never used because nobody in the community was able to operate them, and soon deteriorated due to the lack of maintenance (Castillo and Vera, 1998; Solto, 1999; Bodero, 2003; and MVCS, 2003; Calderon, 2004).

The second important regulatory period occurred in the mid-2000s when a different approach was adopted in the rural areas. This involved the delegation to the JASS of the construction and operation of the water systems, and more responsibilities to the regional and local authorities to supervise these communal organizations. In 2002, the new government of Alejandro Toledo created the Ministerio de Vivienda, Construcción y Saneamiento (MVCS), which is at present the department responsible in Peru for the water policy, and in 2003 the Ley Orgánica de Municipalidades (LOM) established that provincial and local authorities were ultimately responsible for managing, regulating and supervising the provision of the water and sanitation services.[16] In some rural areas, the lack of economic resources of some municipalities made it difficult to attain these goals, and so in 2005 the MVCS modified the water regulation and set the JASS responsible in rural population units for the delivery of the water services. This reform had important consequences because it introduced the dual provision system that is present today: in the urban areas of the municipalities the provision of the service is to be carried out by EPS and regulated by SUNASS while in the rural population units the service is to be operated by JASS and supervised by the local and regional authorities.

More precisely, the current organization of the water service in Peru is as follows. In the urban population units, the majority of households are either served by an EPS or by the local government that is, there is public provision. There are 54 EPS supplying the service to around 60% of the country's population whereas local governments provide the service in more than 220 small cities not covered by EPS, which represent 9% of the country's population. Privatization has a very limited presence in Peru. In 2005, some municipalities in the Department of Tumbes privatized the water service but this policy has not been extended to other departments partly due to the opposition of the population and the concerns on the governance problems

[16] The LOM 2003 (Ley 27972) does not clarify how local governments can assist the JASS in their activities, but municipalities must supervise, give technical assistance and help the expansion of the water infrastructure.

associated with privatization.[17] Finally, some households in urban areas obtain water from private wells, communal organizations, or from small scale local operators that might supply water through tankers, barrels, small networks and other systems. The reason for these alternative providers is that EPS do not cover all their territories and some households can not afford the prices. The fees set by these alternative providers are not regulated and usually the service does not follow any quality control (MVCS, 2007).

In the rural population units, the JASS constitute approximately 85.5% of all the organizations providing the water service that is, there is communal provision. The JASS operate and maintain the water systems, set the fees, construct and supervise the creation of new projects. In the rest of cases, local governments take care of the service (Rojas, et. al 1999, and Calderon, 2004).[18]

Most of the support offered to rural communities is channelled through investment institutions. In 2003, the MVCS created PRONASAR (Programa Nacional de Agua y Saneamiento), a program that financed and coordinated the creation and rehabilitation of water systems.[19] The communities had to propose projects to PRONASAR which then selected the projects taking into account their efficiency, equity and the needs of the communities. An important characteristic of this program was that it promoted the participation of rural organizations and local governments in the design and development of the projects.[20] It also gave training to the JASS and technical assistance to the municipalities. In 2012 the Programa Nacional de Saneamiento Rural (PNSR)

[17] The first attempts to privatize public firms like SEDEPAL occurred in 1995 Tamayo et al. (2000). Yet, the first private concession was signed in 2005 in the Department of Tumbes. The winner of the tender (Aguas de Tumbes) received a concession for 30 years, and was committed to make investments to reach some expansion and quality objectives (increase coverage from 56% to 95% in 5 years, and increase service continuity from 7.3 hours to 23.5 hours). This had to be compensated by an increase in fees. However, failure to meet the expansion objectives led the owners of the firm to sell it to Aguas de Manizales de Colombia in 2011 (Salinas, 2013).

[18] There are also some small rural population units that are not attended by either local governments or formal communal organizations.

[19] PRONASAR was partly financed by the World Bank. More generally, an important part of the resources used in rural areas come from international cooperation organizations like the Agencia Suiza para el Desarrollo y la Cooperacion (COSUDE), the Canadian cooperation (ACDI), the PAS-World-Bank, or the Agencia Interamericana de Desarrollo (AID).

[20] Community members participated actively in many aspects related to the planning of their water systems, such as the site of the project, the fees or the choice of technology. Projects gave women a more important role in the decision-making process, and required households to pay all of the operation and maintenance cost and at least a part of capital costs (Sara and Katz, 1997; Whittington et al., 1998 and 2009).

replaced PRONASAR. The general objective of this program is to increase access to water and sanitation services for the population living in rural areas and to improve the sustainability of water systems. PNSR has focussed in communities with high needs and high prevalence of water related diseases in children under five. It gives priority to the rehabilitation of water systems, the training of the JASS and the health education of the population. In rural areas, PNSR implements the so-called Project Cycle which involves a three-stage process. First, it promotes the creation of a JASS and a supporting unit in the local government (Area Tecnica Municipal or ATM). If the JASS already exists, the program initiates its legal recognition. Second, the members of the JASS are trained. And finally, the JASS undertakes the management, operation and maintenance of the service with the supervision and assistance of the ATM.[21]

4.2 The Juntas Administradoras de Servicios de Saneamiento (JASS)

4.2.1 Legal structure and general aspects

The JASS are civil associations that manage the water and/or sanitation services in many rural and peri-urban areas of Peru. They were first legally recognized in the Ley General de Servicios de Saneamiento of 1994 which also established that in rural population units of less than 2,000 inhabitants the provision of water services had to be organized by communal action. However, it was not until 2003, with the Ley Organica de Municipalidades, that this measure was detailed out and enforced. The Ley Organica de Municipalidades urged local authorities to promote the creation of JASS and supervise the provision of public services. Municipalities also had to give financial and technical support to the JASS according to their possibilities, and resolve disputes among their members. The JASS, in turn, had the obligation to be legally registered and were set responsible for running the water service in rural pop-

[21] PRONASAR and PNSR have been complemented by other programs. For example, in 2006, the government of Alan García declared an emergency situation in the water sector and approved a plan to expand the networks and improve the quality of the water. In 2007 the government approved Programa Agua Para Todos (PAPT), a program aimed at facilitating access to the service to the most vulnerable population in the country. This program has transferred an important amount of resources to local and regional authorities and to the EPS for the construction and rehabilitation of water and sewage infrastructures.

ulation units, maintaining the infrastructures and supervising the construction of new ones, setting household fees and penalizing the users that did not meet their obligations. In 2010 the government passed a new law that regulated the JASS.[22] Its main purpose was to establish the process to elect and renew their representatives and to guarantee the transparency and accountability of these organizations.

The institutional structure of the JASS consists of a general delegate assembly, a management board and a supervisory board that has veto power over the management board. The assembly is composed of all the members of the organization. It approves the statutes of the organization, its rules, and the board. It also chooses the supervisory board. Every year the assembly has to approve the work plan, the annual budget, and the household fees. The management board must include at least five people (President, Secretary, Treasurer, and two additional chairs) and it is in charge of managing the water system. There is no specific regulation that explains which are the technical and financial activities that the board must undertake, but it usually proposes the household fees, bills the water, collects the payments, establishes a penalty system, elaborates the annual budget and the work plan. Regarding the infrastructure, it supervises the installation of household connections, standpipes, sewerage and sanitary latrines. Finally it also represents the organization vis-a-vis national agencies (such as SUNASS , the municipalities or health centres) and international bodies (NGOs, World Bank and others). The members of the JASS have the right to use the water services and be part of the management board or the supervisory board. In return, they must pay a household fee and participate in the construction, rehabilitation and maintenance of the infrastructures. Each family is also responsible for maintaining its own connection. The families that do not participate in the community activities need to pay additional fees.

The JASS face several economic difficulties and limitations, which is to be expected given that they are usually the water provider in rural and remote communities that are too poor to have a public water system. This partly explains why the fees charged by the JASS tend to be lower than those charged by public firms, and why many families do not pay for the water service.[23]

[22] See Resolución Ministerial No 205-2010-Vivienda and Resolución Ministerial No 207-2010-Vivienda

[23] It is estimated that half of the rural households do not pay for water services Enaho (2011).

When the revenues collected do not cover the operating and maintenance costs, the JASS need to ask their members for additional payments or collective works, and in many cases this is still not enough to finance their activities, hire qualified staff and buy materials. Moreover, the lack of resources limits the ability of the JASS to implement subsidization schemes to help low-income households.

Some JASS receive external training, especially those that participate in projects financed by PNSR or international donors, but many others do not receive any support. As a result, a number of JASS lack technical protocols to treat the water and often the chemicals needed are not affordable by the community and must be supplied by the public administration. Also, rural communities have very little access to education on how to improve the health habits of the population.[24] Finally, it is worthwhile mentioning that some JASS have created second-tier associations, such as the Asociaciones de Juntas Administradoras (AJASS), that seek to strengthen the representativeness of their members in public and private agencies, provide training and centralize the procurement of inputs in higher amounts as to decrease operating costs (Pou and Campos, 2001).[25]

4.2.2 Explaining the presence of the JASS

As explained above after the legislative changes introduced in the 1990s and 2000s, the JASS became the designated organizations to provide the water services in the rural areas (or rural population units) of Peruvian municipalities while the urban population units were to be served by public systems. In practice both types of provision, communal and public, are still present in rural and urban population units. However, the JASS and other types of communal provision are much more prevalent in rural population units.

The existence of communal water systems is also related to the difficulties of public authorities to set up and manage the water service themselves. Often, municipalities lack the financial and the appropriate technical and hu-

[24] In spite of this, Calzada and Iranzo (2014) find that in rural communities the children that access the service through the JASS are less likely to suffer from water-related diseases than those that obtain water from public systems. This suggest that rural communities might be more effective in managing the service than local public administrations that might also face economic difficulties and have a reduced presence in the community.

[25] A small group of JASS has created a national association called Red Agua Segura that offers training to the communal workers (www.gestoresdeaguasegura.org).

man resources to run the service. Moreover, in small and remote communities the provision of water can also be technically challenging and financially very costly because economies of scale cannot be exploited. Thus, the JASS become the default water provision system in poor and remote municipalities.

Another important determinant of the JASS has to do with the history of Peru and other Andean countries. The JASS find their historical roots in the Minka tradition of communal work used during the pre-Columbian Inca civilization to build roads and public buildings, as well as in some agricultural activities. As descendants of the Incas, the ethnic group of the Quechuas has maintained the tradition of communal work. Hence, we would expect the JASS to be more prevalent in municipalities with a large presence of Quechua population. Related to this, the literature on collective action points out another potential explanatory factor for the emergence of communal organizations: the cultural and ethnic composition of the communities. It has been argued that the creation and viability of such organizations and the provision of certain public services are more likely in more homogeneous communities. For instance, Barnerjee et al. (2008) argue that some important characteristics of the community for collective action are the shares of different ethnic groups, social heterogeneity and income inequality. Several papers have empirically analysed the relevance of social composition in the provision of public goods. Miguel and Gugerty (2005) consider the effect of ethnic heterogeneity on school spending in western Kenya, obtaining a negative effect of ethnic heterogeneity on public spending on schools, maintenance and per pupil availability of desks and textbooks. For India, Barnerjee and Somanathan (2007) find that standard measure of ethno-linguistic fragmentation applied to caste and religious divisions was negatively related to access to several public goods in the early 1970s.[26]

We use simple regression analysis to assess the importance of the above determinants in explaining the access to water of Peruvian households through communal organizations. The data come from the ENDES Survey (*Encuesta Demográfica y de Salud Familiar*) which is a detailed, nationally representative survey at the household level elaborated by the Peruvian Statistical Institute that every year interviews thousands of households in Peru. We use the years between 2006 and 2010, that include over 50,000 observations. Among others,

[26] For other related work, see also Alesina and La Ferrara (2000), Barnerjee et al. (2008), Alesina et al. (2012) or Glennerster et al (2013).

the survey contains information about the type of water provider, characteristics of the service (payments, water availability, etc.) as well as several variables describing the living conditions, health and socio-demographic characteristics of the households. In the pooled sample for 2006-2010, almost 50% of the households reported obtaining the water from a public operator, 44% from a communal organization (JASS and others), 3.6% from a private operator, and about 2% from another type of private firm. As private provision accounts for a very small percentage of households and they are geographically concentrated in one region (Tumbes) we do not consider it here. We estimate the following empirical model:

$$Communal_{hmt} = \alpha + X_{mt}.\beta + \delta_r + \eta_t + \epsilon_{hmt}, \tag{1}$$

where h indexes the household, m the municipality and t the year. The variable $Communal_{hmt}$ is a dummy that takes value 1 if the household obtains the water from a JASS (or another communal organization) and 0 if it obtains it from a public system (that is, a public firm or a local government); X_{mt} denotes the different explanatory variables we consider. In all the regressions we include region and year fixed effects, δ_r and η_t respectively, to control for unobserved heterogeneity across regions and years. Finally, ϵ_{hmt} is the error term.

Table 2: Explaining the presence of communal organizations

Dependent variable: Water obtained from a JASS or another communal organization								
Explanatory variables:	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Rural population unit	0.5339***	0.5371***						
	(0.0235)	(0.0233)						
Per capita professional personnel in municipality		-10.4925**						
		(4.6365)						
Altitute (in meters)			0.0001***					
			(0.0000)					
First Inca period				0.2854***				
				(0.0957)				
Second Inca period				0.2554***				
				(0.0806)				
Third Inca period				0.5153***				
				(0.0742)				
Fourth Inca period				0.2447*				
				(0.1304)				
Share of Quechuas in municipality					0.7168***			
					(0.0704)			
Lang. homogeneity --incl. Spanish						-0.0378		
						(0.1630)		
Lang. homogeneity --excl. Spanish							0.3575***	
							(0.0943)	
Lang. homogeneity --excl. Spanish, weighted by non-Spanish share								0.7966***
								(0.0614)
Region Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Observations	53,404	53,140	53,404	53,292	53,268	53,268	53,114	53,114
R-squared	0.309	0.310	0.144	0.141	0.173	0.130	0.140	0.190

Notes: Robust standard errors in parentheses clustered by municipality, *** p<0.01, ** p<0.05, * p<0.1
Data from ENDES 2006-2010; unit of analysis: household.
See the text for adetailed description of the dependent and explanatory variables.

Estimation results are reported in Table 2. Column I shows that households in rural population units, (sub-units of municipalities classified as rural) are more likely to be served by communal organizations. The point estimate, which is clearly statistically significant, suggests they are 54 percentage points more likely to have communal provision than households in urban population units. As indicated by the R-squared of the regression, together with the region and time fixed effects this variable explains 31% of the variability in the type of water provision across households. As apparent in the other models, out of all the explanatory variables examined, the administrative classification of population units as rural or urban is the best predictor for communal water provision.[27] This result is in line with the legislative changes of the 2000s that effectively set the JASS responsible for the provision of water in rural population units. The management of a water system also requires qualified personnel and so the municipalities that do not have the appropriate technical personnel should be less likely to directly organize the provision of the service. To test this, on Column II we add the per capita professional personnel of the municipality (that is, the personnel classified as either "professional" or "technical")[28] which is indeed negatively and significantly correlated with the probability of communal provision. However, this variable increases only slightly the overall explanatory capacity of the model. In order to capture the costs of remoteness, on Column III in Table 2 we consider the altitude of the municipality (in meters). Although the coefficient is small in magnitude, households located at higher altitudes are more likely to have communal provision.

We use two proxy variables to assess the importance of the Minka tradition of communal work: the share of Quechuas in the municipality total population and a set of dummy variables reflecting the historical settlements of Incas in Peru.[29] The Inca Empire emerged in the Andean region in the XV and XVI centuries. Its geographical expansion was initiated in the Cuzco region around 1438, and continued until 1534 when the Spanish troops of Francisco Pizarro entered Cuzco and completed the conquest of Peru (Espinoza, 1997).

[27] A simple model with just region and fixed effects explains 13% of the variability. Thus the contribution of the classification of population units in the overall explanatory power of the model is considerable.

[28] This variable is obtained from the National Registration of Municipalidades (RENAMU) which contains information about the employees and the equipments of the Peruvian municipalities.

[29] Notice that in addition to reflecting the importance of the Minka tradition, the share of Quechuas could be capturing other cultural aspects associated to communal provision. Thus, it is important to use a more direct proxy reflecting the historical roots of communal work.

During this time we can identify four phases in the expansion of the Inca Empire which are used to approximate the period of time in which each region was under the influence of the Inca traditions and norms: (1) Pachacutec (1438-1471); (2) Tupac Inca (1463-1471); (3) Tupac Inca (1471-1493); and (4) Huayna Capac (1493-1523). We created four dummy variables that indicate whether the municipality in question lies within an area dominated by the Incas during each of those four periods. As observed in Column IV households in areas of historical Inca dominance (particularly those of the Tupac Inca period) are more likely to have communal water provision than those that were never under the Inca rule. Likewise, the proportion of Quechuas in the municipality is a significant predictor of the presence of communal water organizations – see Column V. Thus, the link between these organizations and the Minka tradition is also confirmed.

Finally, we explore the role of linguistic homogeneity in explaining the presence of communal water organizations. Besides Spanish (the most commonly used language in the country), there are a number of native languages spoken in Peru, including Quechua (the most important among the indigenous languages), Aymara and Ashaninka. The Census of Peru provides information on the languages spoken in each municipality.[30] We computed the Hirshmann -Herfindahl index to measure the linguistic concentration in each municipality. Column VI on Table 2 shows that the coefficient on this linguistic homogeneity index is not significant, which can be a consequence of the dominance of Spanish as the main language in many municipalities. Indeed, this index mirrors the concentration of Spanish-speaking population across municipalities. As an alternative, we compute a linguistic concentration index for all languages except Spanish[31] (column VII) and weight it with the share of non-Spanish speaking population in the municipality (column VIII). As observed, the existence of communal water systems is positively and significantly correlated with the non-Spanish linguistic homogeneity of the municipality (see column VII) particularly when this is weighted by the share of non-Spanish speaking population in the municipality (see column VIII).

To sum up, the regression analysis conducted shows that the presence of a

[30] There is a wide dispersion in the usage of indigenous languages across municipalities. For example, the percentage of people speaking Quechua or Aymara ranges from zero to close to 100% in some municipalities.

[31] We calculate the shares of each language with respect to the overall non-Spanish speaking population and compute the Herfindahl concentration index accordingly.

JASS in an area is associated with its geo-demographic and cultural characteristics, and importantly to the regulatory setting. JASS are prevalent in small and less dense areas of the municipalities (the rural population units) and in municipalities with less technical and economic resources. We also confirm the hypothesis that cultural and historical factors, measured by the concentration of Quechuas and the historical settlements of Incas, are important determinants of communal organizations.

4.2.3 Performance and sustainability of the JASS

Despite their importance, there is a lack of studies assessing the efficiency and performance of the JASS and other communal organizations in Peru. There are some studies analysing the quality of drinking water and the performance of the water systems in rural areas in Peru but they do not consider this type of provision.[32] Yet, in order to design adequate policies, it is essential to know how well communal organizations do in providing water services. In this section, we present some analysis comparing the performance of communal organizations versus public water systems along several dimensions of the service. Using the household data from ENDES described above, we estimate the following empirical model:

$$PI_{ht} = \alpha + \beta.Communal_{ht} + X_{ihmt}.\gamma + \delta_r + \eta_t + \epsilon_{ht} \quad (2)$$

where PI_{ht} is a performance indicator at the household level h; $Communal_{ht}$ is a dummy variable that takes value 1 if the household has access to water through a communal organization and 0 if it is through public provision; X_{iht} is a vector of controls that includes individual characteristics of the person i living in the household, characteristics of the household h and some controls at the municipality level; δ_r and η_t are region and year fixed effects respectively, and ϵ_{ht} is a disturbance term. Regarding the individual characteristics we control for the educational level, age and ethnicity. Among the controls at the

[32]For example, CEPIS (1999) analyzed 80 systems located in rural areas of Peru and found that only 37.5% of them were performing chlorination treatments and that 63% of the systems presented a high health risk. More recently, Miranda et al. (2010) shows that only 0.5% of the children in rural households drink water treated with chlorine, compared to 24.2% of the children in urban areas, and DHS (2011) finds that only 0.6% of households in rural areas use water with a suitable dose of chlorine. Moreover, only 4.9% of children in rural areas have access to water with absence of coliforms and E. coli, whereas this percentage is 44.4% for children living in urban areas.

household level we include the income level, assets (whether it has electricity, fridge, vehicle, shared toilet, etc.), the number of household members and, in most models, we also control for the source of water. That is, whether the water used by the household comes from a pipeline inside or outside the house, a public tap, a well inside the house or a public well, a water spring, a river or lake, whether it is rain water, bottled water or others. Finally, we control for the population and the per capita professional personnel of the municipality.

The performance indicators we examine are the following: the household average monthly water payments, the per capita average water payments, access to piped water (either inside or outside the house), 24-hour availability of water, water storage and time to collect water. The first two indicators give an idea of the affordability of the system and should be correlated to coverage rates. The other indicators are (more or less direct) measures of water quality and quality of the service. For example, piped water is considered to be safer than other sources of water such as wells or public taps because it is usually treated. Similarly, the storage of water is related to water quality not only because pathogens tend to develop in stored water but also because often the containers used to store water are contaminated. Finally, 24-hour availability and time to collect water are both indicators of service quality as it is more convenient to have uninterrupted and easily access to water. Moreover, uninterrupted access to water fosters the use of water for hygienic purposes, which might have additional positive effects.

Table 3: Performance indicators of the water service

Dependent variable:	Water Bill (I)	Per capita Water Bill (II)	Piped Water (III)	Water 24h (IV)	Store Water (V)	Time to Collect Water (VI)
Communal provision	-6.8450***	-1.5068***	-0.1662***	0.0717***	-0.0057	0.4443**
	(0.5107)	(0.1468)	(0.0194)	(0.0215)	(0.0100)	(0.1946)
Mother controls	YES	YES	YES	YES	YES	YES
Household controls	YES	YES	YES	YES	YES	YES
Municipality controls	YES	YES	YES	YES	YES	YES
Region Fixed Effects	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES
R-squared	0.360	0.304	0.157	0.163	0.218	0.382
Observations	32,344	32,344	33,519	24,050	24,968	31,896

Notes: Robust standard errors in parentheses clustered by municipality, *** p<0.01, ** p<0.05, * p<0.1
Data from ENDES 2006-2010; unit of analysis: household.
See the text for adetailed description of the dependent variables and the controls.

Table 3 reports the estimation results. Columns I and II show that households served by JASS pay on average lower monthly bills, in absolute terms and per capita, than those served by public systems. This is partly due to the compensation that users received for their volunteer work in the construction, maintenance and operation of the communal systems. Lower water fees facilitates the access to the service and so it is a positive aspect of the JASS. However, if the revenues of the JASS are insufficient to pay for the operating and infrastructure costs, low fees might also contribute to the deterioration of rural water systems.[33] Column III shows that access to piped water, whether inside or outside of the home, is less common for households served by communal organizations than it is for households served by public systems, and this correlation is statistically significant. This is not surprising given that the JASS usually lack the financial resources to build and maintain the pipeline network. By contrast, communal provision is positively associated to uninterrupted service (column IV). This might have positive implications for the health of the population since a continuos service encourages a higher use of water and reduces storage. Indeed, column V confirms that JASS users tend to store water less, although the coefficient fails to be statistically significant. Finally, Column VI shows that JASS users spend more time to collect water, which is consistent with the lower access to piped water in these organizations.

All in all, this analysis suggests that despite the economic difficulties faced by the JASS these organizations are still capable of providing water services to populations that would otherwise not be attended by public (or private) systems. Moreover, the crude quality measures examined here suggest that they do so at reasonable standards.[34] Thus, it seems as if the JASS are compensating for their financial and technical deficits with the volunteer work of their members, higher knowledge of the actual needs of the community and increased incentives to provide a safe water service.

Another essential aspect in the design of any water policy is the sustainability of the water systems. A system is considered to be sustainable if the infrastructures last at least 25 years.[35] The Peruvian government and several international institutions have developed a number of pilot projects to analyse the sustainability of rural water systems. With respect to earlier ones,[36] recent

[33] In a study examining water projects in 400 communities in Bolivia, Peru, and Ghana, Whittington et al. (2009) find that the fixed monthly fees charged to households was very modest, and that less than half of the communities could recover costs through the fees.

[34] In a more exhaustive study, Calzada and Iranzo (2015) also find that communal water provision in Peru results in improved child health outcomes.

[35] According to MVCS (2003), this requires an adequate design of the facilities; the promotion of healthy habits in the population; the environmental protection of the hydric resources; and the supervision of the systems to guarantee their maintenance of the facilities and the participation of the community.

[36] In 1999, a study by the Water and Sanitation Program of the World Bank (WSP)

studies report an improvement in the sustainability of the systems, although results are sensitive to the particular definition of sustainability used and the systems analysed. Whittington et al. (2009) analyse a group of rural communal organizations and conclude that many of them have succeeded in maintaining their system under acceptable conditions. However, they argue that most of their efforts are devoted to repairing, rather than maintaining, the systems. MVCS (2011) reports that only 30% of the systems are economically sustainable, 40% are in deficit and in the remaining 30% users do not pay for the service. Finally, ENDES (2011) explains that one of the reasons for the lack of sustainability of water systems is that less than 60% of them are managed by a JASS and only 14% of them have a member that had received some training to operate the system. The deterioration of water infrastructures is also explained by the lack of involvement of the community in public projects (MVCS, 2006) which altogether suggests that communal water organizations can also help to the sustainability of the systems.

4.3 New management systems in rural areas

In the last years, new management systems have been introduced in some parts of Peru to intensify the supervision of local communities and the use of specialized personnel to operate and maintain the water systems. After a sustainability study carried out in the region of Cuzco, agencies called Sanitation Offices (Oficinas de Saneamiento) were created in a number of municipalities in the region with the objective of giving technical support and training to the JASS. Most municipalities contracted personnel to run these offices and endowed them with financial resources. In Cuzco, these agencies give support to 105 JASS. The success of this experience has stimulated the creation of similar agencies in other regions, although some municipalities are reluctant to devote resources to them.

Another innovative project was developed in 2003 by the MVCS in collaboration with the Water and Sanitation Program (WSP) of the World Bank

showed that only 31.7% of rural systems were sustainable, while 22.1% and 1.9% were very deteriorated or had collapsed respectively. These results were later confirmed in 2003 in research undertaken by the MVCS in preparation for the program PRONASAR. The program PROPILAS, that replaced PRONASAR, examined the sustainability of water services in five provincial municipalities (Cutervo, Hualgayoc, Jaén, San Marcos and San Pablo) between 2006 and 2008 and showed that in most municipalities the percentage of sustainable systems was less than 1 %.

and financial support from the Canadian International Development Agency (CIDA). They implemented a pilot project called Proyecto Piloto Pequeñas Localidades (PPPL). The key aspect of this project was the introduction of specialized operators (Operadores Especializados, OE), small private or mixed operators that are in charge of maintaining and operating the water system. They obtain the concession from a tender and usually are managed by people in the local community. The project was initially carried out in 9 small municipalities; 5 of which opted for a regional private operator, 3 chose a mixed local firm and one opted for a national private operator (WSP, 2007). The project favours the coordination between the municipality, the community association (Junta Vecinal de Vigilancia del Agua) and the OE. The municipality is the owner of the infrastructure and sets the fees and the coverage of the service with the agreement of the community. The community association informs about the project, channels the claims of the users, supervises the operation of the OE, monitors bill collection and runs health and hygiene programs, all this with the assistance of the municipality. An interesting characteristic of this project is that the OE has to offer the community a menu of different rates and qualities (household connections, standpipes, types of treatments for the water, characteristic of the sewerage system, etc.) and then the community chooses one option according to the needs and financial resources.

Finally, the governance problems of the JASS have led some communities to create alternative water organizations. For example, in 1997 the inhabitants of the municipality El Ingenio (in the region of Ica) left the JASS and created a users' association which adopted a new management system agreed upon by all the users.

The evaluation of these new management models, particularly the specialized operators, shows positive results in terms of coverage of water and sanitation services, continuity of the service, and payments (WSP, 2008). Hence, PNSR is now extending the management system based on specialized operators to other small towns. In the years to come it will be interesting to assess in detail the performance of this alternative management model.

5 Conclusions

Communal water organizations are prevalent across countries in Latin America and constitute the default type of provision in poor and disperse rural communities in which local governments lack the necessary economic and technical resources to provide the service. In Peru most of these organizations take the form of Juntas Administradoras de Servicios de Saneamiento (or JASS). After a process of administrative and political decentralization, in the early 2000s the Peruvian government transferred to the JASS the responsibility of planning, constructing and operating the water systems in rural areas. This meant the acceptance and legal recognition of this type of provision system that had been informally used in the country for decades.

In this chapter we show that the presence of JASS and other communal organizations in Peru is related to the ethnic and socioeconomic characteristics of the municipalities, and particularly to the influence of the Minka tradition of communal work dating back to the Inca civilization. Communal water organizations are more likely in municipalities with a large percentage of the ethnic group of Quechuas and in areas where the Inca settlements used to be. The JASS also tend to be the provision system in municipalities with fewer technical and professional resources capable of operating the service and, due to the regulatory changes introduced in the 1990s and 2000s, they are also prevalent in the rural areas of the municipalities, in the so-called rural population units.

Based on the empirical analysis conducted here, Peruvian communal water organizations do not appear to perform significantly worse than the public systems. First, the fees charged by the JASS are lower than those set by public firms or local governments, which facilitates the access to water of groups of the population that would hardly be served by public or private providers otherwise. As a downside, the fees charged by the JASS do not always cover the costs of operation and maintenance of water systems, and in some instances these infrastructures get deteriorated. Second, although access to piped water is less common in the JASS, the quality of the water service, at least based on the indicators examined here, does not seem to suffer significantly. Communal systems offer more uninterrupted service and the storage of water is lower than in the case of households served by public operators and local governments. Thus, the JASS seem to be compensating for the lack of financial and technical resources with the volunteer work of their members, their higher incentives to provide safe water and their higher knowledge of the needs of the community. All in all, the analysis of the Peruvian experience suggests that despite the limitations of the communal organizations, they might be a cost-effective way to provide water services in rural regions of developing countries.

The challenge for the next years is to develop management models to complement the work of the JASS and help them improve their performance. For example, institutions like the Oficinas de Agua that give training and technical support can help the JASS in maintaining the water infrastructures. Another way to improve the performance of the water service in rural communities is by means of specialized private operators that can run the water system under the supervision of the local community. The key element of this model is that the local communities keep the ownership of the infrastructures as well as the supervision of the service so that it is not perceived as the sector has been privatized, while the service is operated by a specialized firm. In the years to come it will be interesting to also assess the performance of these alternative management models.

Chapter IV: LPG Cook Stoves in Peru: Evaluation of the FISE Program[1]

1 Introduction

An important part of the world population does not have access to modern energy sources. 1.26 billion people are still without access to electricity and more than twice as many people use biomass for cooking (Bonjour et al., 2013).[2] This situation creates a major health problem in developing countries since pollutants emitted by traditional solid fuels in inefficient stoves generate Indoor Air Pollution (IAP), which is a major factor of premature deaths (Bruce et al.,2000; Lim et al., 2012; and WHO, 2006a). According to WHO (2005), 19% of mortality in infants under 5 years is caused by Acute Respiratory Infections (ARI), which is the second cause of infant mortality worldwide. In Peru, around 6.4 million people do not use modern and clean energy sources to cook. More than 50% of households in the rural areas usually use kerosene, wood or charcoal for cooking. As a consequence, lower respiratory infections are the leading cause of morbidity and mortality in children under 5 years: 2,355 children under age 5 die every year because of these infections, which represents 15.52% of total mortality in children (Global Burden of Disease, 2010).

The recognition of this health problem has led several international organizations and national authorities in many developing countries to dedicate part of their efforts to the replacement of traditional wood stoves for more efficient and healthy ones. Organizations such as Global Alliance for Clean Cookstoves (GACC), the World Bank or the EnDev Project (Energising Development) are funding programs to promote the use of clean kitchens in developing countries. Most of these programs are for African and Asian countries, but there are also projects in Latin American countries like Bolivia or Peru. Many programs have also been developed at the national level. For example, in India, the National Biomass Cook stoves Program was initiated in 2009 with the objective of providing 160 million households with improved cook stoves (ICS) that use solid

[1] Joan Calzada and Alex Sanz

[2] Elias et al. (2005) show that 90% of the energy use of poor households in developing countries is due to cooking. The main reasons for this are the households' cultural and socioeconomic characteristics, availability of fuels, environmental characteristics of the kitchens and governmental policies. See also Leach (1992) and Masera et al. (2000).

fuels (Venkatamaran et al. 2010). In Guatemala, the Ministry of Energy and Mines in the Mines Energy Policy 2013-2027 aims to install 100,000 healthier cook stoves in the country (GACC, 2014b). The objective of this chapter is to evaluate the FISE (Fondo de Inclusión Social Energético) program in Peru, which is a public program that tries to replace traditional stoves for LPG stoves in the poor households and municipalities of the country. In this chapter we describe the main characteristics of the program and examine its effects.

In 2012 the Government of Peru created the "Fondo de Inclusión Social Energético" (FISE), which promotes the access to clean energy to the most vulnerable population and reduces energy inequality in the country. The two main instruments used by the FISE are the free delivery of LPG cook stoves and the concessions of monthly vouchers for the purchase of LPG cylinders. The households' beneficiaries of the program can receive a voucher per month, which reduces significantly the price of LPG. To participate in the program households must have a consumption of less than 30 Kwh per month and an annual income lower than 18,000 nuevos soles.[3] To evaluate the results of the program we use a survey conducted in 2015 by OSINERGMIN (the Peruvian regulatory agency for the energy sector) in the municipality of Ayacucho (Huamanga).

Our analysis shows that the use of clean energies is much more frequent in high income households. Using data from Huamanga, we show that in the richest quartile of the population, 28% of the households use clean fuel for heating, while in the poorest quartile the figure drops to 7.5% of households.[4] We find similar results when we examine the type of kitchen used by households. The increase of family income reduces the use of firewood cook stoves and increases the use of LPG cook stoves. On the other hand, family income is also related to the ratio of meals that are cooked with LPG stoves weekly. Among the households that use LPG stoves, while the highest income quartile cooks about 75% of the weekly meals with LPG stoves, the lowest quartile only cooks 56% of the meals with these stoves.[5] This result implies that poor households need to combine the use of LPG stoves with traditional ones, which are more contaminant and can generate respiratory problems. This situation would justify the use of subsidies to promote the use of clean energies by the

[3] Peruvian minimum wage amounts to 750 nuevos soles (250 $)
[4] For more results see Table 15.
[5] For more results see Table 17 and 18.

most vulnerable population.

The second part of the chapter assesses the effects of the FISE program in the beneficiary population of Ayacucho. Specifically, we examine the effect of the program in the weekly number of meals cooked with LPG stoves, the respiratory and cough problems of population, the use of kitchens to boil water, and number of days that children miss school due to respiratory and water related diseases. For this objective, we first use the information of both users and non-users of LPG cook stoves in the municipalities surveyed to estimate a probit model with the participation status of households as dependent variable. We then use the estimated model to predict probabilities of participating in the program for all households in the sample. Finally, we use these probabilities to identify counterfactual households using matching algorithms. Specifically, we separate the households that do not participate in the program into those that are likely to participate taking into account their observed characteristics and those that are not. We refer to the former as hypothetically beneficiaries and compare them to the actual beneficiaries in Ayacucho. To do so we use two classical matching methodologies, nearest neighbour and Kernel.

Our analysis shows that the FISE program has succeeded to increase the use of LPG as cooking fuel, and that this increase is especially important in the lower strata of the population. In spite of this, it seems that the price of LPG cylinders has prevented a complete replacement of traditional stoves for LPG ones. On the other hand, the empirical analysis does not find a direct link between the reception of the voucher and a reduction of cough or breathing problems in the beneficiary households. Moreover, vouchers do not seem to reduce the number of days that children miss school due to respiratory problems. A possible explanation for this result is that beneficiary households continue to use firewood for cooking some of their meals and for heating purposes. Hence, the use of LPG stoves is not enough to reduce intra-household contamination. Another interesting result of our analysis is that the voucher enables the use of LPG stoves to boil the water. Indeed, households might be using LPG stoves to boil the water because it requires less time. We also find that in households that benefit from the program children miss less schooling days due to diarrhoeal problems.

The structure of the chapter is as follows. Section 2 offers a revision of the literature. Section 3 reviews the main characteristics of the FISE program. Section 4 explains the data set and the methodology applied for analysing the impact of the FISE program. Section 5 shows the main results of the chapter and, finally, section 6 concludes.

2 Background

There is a wide consensus in the literature that one of the most important determinants for the use of traditional cook stoves in developing countries is the households' socio-economic situation. According to the "energy ladder" theory, households replace traditional fuels by more efficient ones when their socio-economic situation improves (Hosier et al., 1987). More specifically, this theory envisions a three-stage replacing process: initially poor households rely on biomass; as their income increases they switch to "transition" fuels, such as charcoal, coal and kerosene; finally households with a higher income move to clean fuels, such as LPG, electricity or natural gas. However, recent studies have shown that households usually consume a portfolio of fuels instead of just focusing in one type, and that they use them to perform different tasks (Barnes and Qian, 1992; Hosier and Dowd, 1987; Hosier and Kipondya, 1993; Heltberg 2004; Heltberg 2005; Masera et al. 2000; Pachauri and Spreng, 2003). For example, ESMAP (2003b) reports that in Brazil the increase in revenues leads to a decrease in the use of traditional fuels, but that the complete substitution is made only at the highest income level. Similar results are found in the use of fuels for cooking, since many households use more than one type of fuel (Parikh, 2011, Ruiz-Mercado et al., 2011).

Several studies have found that income is the main factor determining the fuel used for households when cooking (Bansal et al., 2013; Heltberg, 2005; Nlom and Karimov, 2014). Moreover, it has been found that the use of firewood decreases as family income increases (Ouedraogo, 2006; Arthur et al., 2010). In spite of this, these studies are not conclusive. For example, Arnold et al. (2006) and Cooke et al. (2008) find that income elasticity of the demand for firewood is not significant. Hiemstra-van der Horst and Hovorka (2008), Brouwer and Falcao (2004), Bhagavan and Giriappa (1995) obtain that households of different economic strata use wood as fuel. Davis (1998), Campbell et al. (2003) explain that there are low incomes households that use electricity and LPG as fuel. Other studies have found that prices are another determinant factor when choosing a particular fuel type. For example, Jain (2010) explains that the price of clean fuels is a key factor for the dependence on traditional fuels in India.

Distance to markets is another key factor for fuel adoption. Rural and remote towns have a high cost to access modern energy (Elias et al., 2005). Even when the population in these areas has access to modern fuels, they might choose not to adopt them or to combine them with other sources because they don't have the assets to use them or because of the high maintenance costs (Chaurey et al. 2004). This situation induces many households to simultaneously use several energy sources (Barnes et al., 2005).

Education is another key factor when choosing a fuel type. Several studies indicate a positive relationship between the educational level of the mother in the household and the use of cleaner fuels. Heltberg (2004) analyses the cases of Brazil, Ghana, Guatemala, India, Nepal, Nicaragua, South Africa and Vietnam and shows that the higher the educational level of the mother is, the higher is the probability of using modern fuels and the lower the incidence of using solid fuels. In a different work, Pandey and Chaubal (2011) found that the number of educated women between 10 and 50 years in the household and the average educational level of the household have a positive and significant impact on the likelihood of cooking with cleaner fuels in rural India.

Household size is also a relevant factor in the households' strategy. Nnaji et al. (2012) show that in Nigeria fuel wood is used by households with a relatively large size. Liu et al. (2003) and Carr et al. (2005) found a direct relationship between the household size and the use of fuelwood and explain that this can be related with the family income and the energy demand. Heltberg (2004; 2005) shows that larger households are more likely to use a wider variety of fuels, both non-solid and solid ones. Of course, these factors can interact with others. For example, Narashima and Reddy (2007) and Andadari et al. (2014) found that in India and Indonesia household spending, along with household size and education level, affect the choice of fuel.

Finally, behavioural and cultural factors such as cooking practices, meals taste or the time required for cooking with each stove might also affect the households' choice of cooking fuel (Heltberg, 2005). For example, Masera et al. (2000) found that in rural Mexico the population continued using fuel wood even after gaining access to modern fuels. A justification for this is that cooking "tortilla" with LPG requires more time and tastes worse. IEA (2006) found similar results in India where households prefer cooking bread in wood stoves.

Another interesting part of the literature has focused on the health benefits of using clean fuels. WHO (2006b) explains the potential benefits for human health and for the local environment to invest in modern fuels and improved cook stoves. They used a cost-benefit methodology to study the effects of using clean energies in Kenya, Sudan and Nepal and found that they have health benefits and reduce medical costs due to reduction of days being sick both in adults and children. Other studies have shown that modern fuels and Improved Cook Stoves (ICS) minimize health risks associated with polyaromatic hydrocarbons (PAH) (Asaduzzaman et al., 2010; García-Frapolli et al., 2010).

Since the objective of this chapter is to evaluate the use of subsidies to promote the adoption of LPG stoves in Peru, it is interesting to highlight that most studies have found that these stoves are the cleanest and most commercially successful (Zhang et al., 2000). There is also a recent literature that has analysed the deployment of LPG cook stoves. Akpalu et al. (2011) found that Ghana's favourite fuel is LPG, especially in coastal areas. Kojima et al. (2011) analysed data from 10 developing countries in Sub-Saharan Africa, South Asia, Latin America and Caribbean and show that the increase of the educational level of the population jointly with the increase in the price of alternative fuels incentive the use of LPG as cooking fuel. Yet the high costs associated with modern fuels, such as LPG, prevents people from fully adopting these energies (Davis, 1998; Elias et al., 2005). Another reason that hinders the expansion of LPG is related to the purchase system. Unlike other fuels, such as kerosene or firewood, LPG has to be purchased in large cylinders, which can dissuade its use, especially among poor households (Foster et al., 2000; Leach 1992; Masera et al. 2000).

Nowadays, the governments of several countries are using subsidy schemes to promote the expansion of LPG. Still, its use is very concentrated in urban and peri-urban areas, where the upper and middle classes are concentrated. In this context, subsidies may entail a regressive component. Arze del Granado et al. (2012) analyse welfare impacts of fuel price increases in 20 countries of Africa, Asia Middle East and Latin America, using data from IMF and World Bank, between 2005 and 2009. They found that the LPG subsidies were largely captured by the upper classes of society. On the other hand, Ouedraogo (2006) analysed the factors determining urban household energy choices in Burkina Faso. He obtained that subsidizing LPG and LPG cook stoves can significantly decrease the use of fuel wood in urban areas.

3 The FISE Program: implementation and characteristics

The FISE program was created by the Government of Peru in 2012 with the aim of improving access to efficient and clean energy (natural gas, solar panels, LPG) to the most vulnerable sectors of the population.[6] One of the most important actions taken by the program has been promoting access to LPG stoves, by granting discount vouchers that reduce the price of LPG cylinders. To the best of our knowledge, this strategy of enabling universal access to LPG stoves to all the population is unique and pioneer in Latin America. Next we explain how this project was implemented and its most prominent characteristics.

3.1 Description of the program

In 2012, the Ministry of Energy and Mines (MINEM) of Peru approved the Plan de Acceso Universal a la Energía 2013-2022 to meet the needs of the most vulnerable population.[7] The objective of this plan is to provide universal access to energy and to increase energy efficiency. One of the projects that have been developed in this regard is the Fondo de Inclusión Social Energético (FISE), which is a social energy compensation system for the low income population. Previously, the government implemented a similar program called NINA which had the objective, among others, of replacing wood stoves for LPG stoves in Lima.

The main objective of FISE is to universalize the access to natural gas for both residential and vehicular uses. To do so, it promotes the use of Natural Gas (NG), Vehicular Natural Gas (VNG), Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG). The program provides funding to promote the development of modern energies and subsidizes access to Liquefied Petroleum Gas (LPG) in the most vulnerable groups of the population. Regarding the case of vehicles, it has enabled the transformation of the national taxi fleet to adapt vehicles for the use of natural gas as a fuel.[8]

[6] The Ley N^o 29852 del 13 de abril del 2012, del Ministerio de Energía y Minas, created the Fondo de Inclusión Social Energético.

[7] Ley N^o 29852. Ley that creates the energy security system in hydrocarbons and also creates the FISE. Ministerio de Energía y Minas. 13 of april, 2012.

[8] This project does not apply to the taxis in Lima.

Although the FISE was initially created by the MINEM, since its creation it has been managed by OSINERGMIN (Organismo Supervisor de la Inversión en Energía y Minería), the national regulatory agency for the energy sector. This delegation was intended to be temporary, but has been extended since then. The MINEM establishes the entry conditions in the market, defines the potential beneficiaries of the vouchers and develops mechanisms to universalize the use of LPG. It also prioritizes the projects to be implemented and defines the strategy for the sector in the medium term. OSINERGMIN manages the program and decides how to distribute its funds.

3.2 Program Beneficiaries

The FISE promotes access to LPG to households located in the poorest districts of Peru. To do so, it offers a discount voucher of 16 nuevos soles ($5) to buy LPG cylinders. The value of the vouchers has not changed since the creation of FISE. To identify the potential beneficiaries of the program, the FISE uses the poverty map that has been created by the Peruvian statistical office (Instituto Nacional de Estadística e Informática, INEI). This map combines information from several reports to calculate the per capita household spending and builds an indicator of poverty and inequality in the districts of Peru. Once the poorest districts are identified, the FISE selects the poor households that can participate in the program. Households in each district are classified into seven stratums. Stratums 1 and 2 of SISFOH[9] (Sistema de Focalización de Hogares) correspond to households classified as extremely poor (20% poorest population); stratums 3, 4 and 5 correspond to poor households without reaching extreme poverty (30% of the population); finally, stratums 6 and 7 are considered non-poor households (50% of the population).

To participate in the program, households must meet several requirements: (1) Reside in a district which presents a high level of poverty; (2) Have an LPG stove, although the MINEM offers stoves for free to users that don't have one; (3) having an electricity consumption lower than 30 kwh per month; (4) Don't have access to the natural gas network;[10] and (5) The household income must

[9] SISFOH is a system of information about the socioeconomic characteristics of households. SISFOH calculates a poverty index of households and classifies them into 7 categories or stratums.

[10] Electricity distributors companies must inform the potential beneficiaries of the program and should explain the requirements to participate. Potential beneficiaries must present their National Identity Document (DNI), deliver the affidavit of possession and use of LPG stove

be lower than 18,000 nuevos soles per year (around $ 6,000) and the home must be made of poor materials.[11] To encourage the use of LPG in households that meet the above requirements but that do not have a gas stove, the program offers for free a kit with an LPG stove and a 10 Kg cylinder. By mid-2014 about 340,000 of these kits were already given.

In 2012 a pilot project was implemented in the province of La Convención (Cusco) and it was found that some high income households were being considered as eligible for receiving the voucher. As a consequence, when the FISE was launched at a national level in 2013, a limit on the household income was introduced and the power consumption limit was reduced from 100 to 30 kwh per month. In addition, to prevent that owners of several houses could receive more than one voucher, it was established that only months with positive power consumption would be considered to calculate the annual power consumption, and that in the case of rented houses the beneficiaries of the voucher would be the renters.

The delivery of the discount vouchers has been delegated to the electricity distribution companies. These must create a census with all the households within their concession areas that meet the criteria to participate in the program.[12] They are responsible for issuing the discount vouchers via an SMS or by stapling them in the beneficiaries' electricity bills.

Figure 1 shows the evolution of FISE beneficiaries monthly since the beginning of the program. At present, FISE operates in 1,715 districts in Peru (92.6% of the total population). It also operates in 100% of the country's regions, being Puno the region with a larger number of beneficiaries, with 136,331 households. Figure 2 shows the evolution of the number of districts with FISE beneficiaries.

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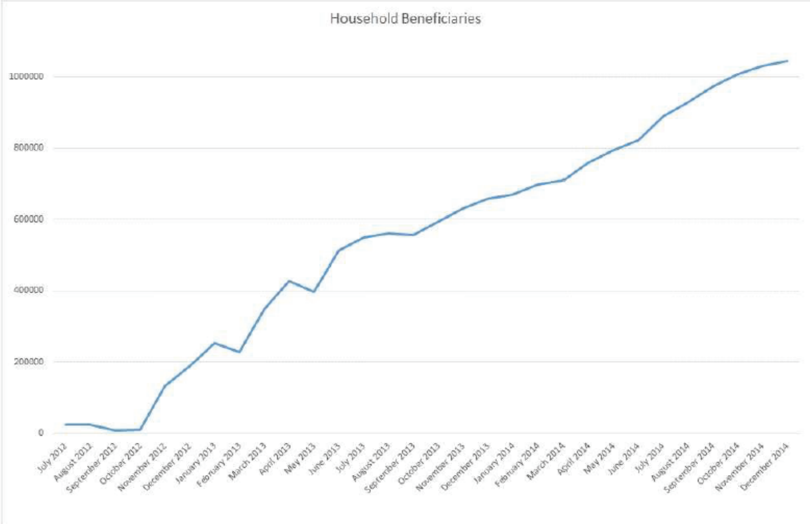
and LPG cylinder, allowing its verification, and present the receipt of electricity consumption. Electricity distributors companies verify this information and that applicants are in the register of SISFOH.

[11] The household may not be eligible for the voucher if the home's predominant wall material is brick or concrete block, if the house has more than one floor, or if the dominant material in the floor is parquet, polished wood, asphalt sheeting, vinyl, tile or terrazzo (or similar).

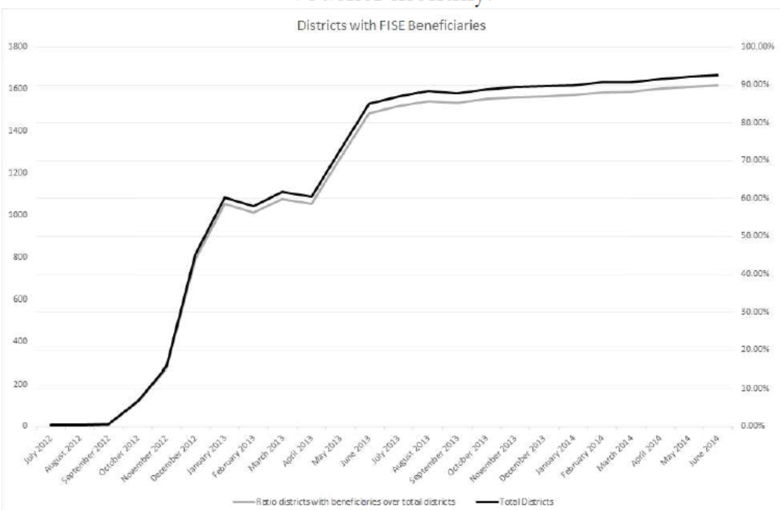
[12] FISE uses the electricity consumption data provided by companies to ensure that the electricity consumption requirements are met. If the maximum consumption is exceeded, households no longer receive their voucher, but may receive it again in the next month if their consumption decreases below the maximum. FISE also has data on household income collected by the SUNAT. If the family exceeds the required limit stops receiving the voucher until next annual review.

Figure 1: Evolution of families beneficiaries of FISE voucher monthly.



Source: Elaborated by authors from Memoria Anual de Gestión FISE 2012-2013 and 2013-2014

Figure 2: Evolution of districts in Peru which have beneficiaries of FISE voucher monthly.



Source: Elaborated by authors from Memoria Anual de Gestión FISE 2012-2013 and 2013-2014

3.3 Project Management

There are three types of agents that participate in the project: the households' beneficiaries of the vouchers, the LPG suppliers (Authorized Agents), and electricity distribution companies. The project beneficiaries are the households that meet the requirements described before. These families receive the voucher in their electricity bill or mobile via an SMS. The voucher allows them to buy an LPG cylinder of 10 Kg at a discount of 16 nuevos soles ($5 approx.) for a maximum period of two months. As the price of a 10kg LPG cylinder is 32 nuevos soles, beneficiaries can buy a cylinder at a zero price gathering the vouchers of two months. Several studies have shown that the average life of a 10 Kg LPG cylinder is longer than one month, because most of the families complement the use of LPG stove with other stoves (improved or traditional).

LPG suppliers have agreements with electricity firms to accept the vouchers as a payment option. Between July 2012 and December 2014 the number of suppliers participating in the program has increased from 5 to 3,285.[13] This is in part a consequence of the implementation of the "digital" voucher in 2013. The creation of the digital voucher was a response to the problems caused by the printed vouchers stapled on the electricity bills.[14]

Initially, the vouchers were issued printed along with the electricity bill. There were delays of around 15 days between the date on which the LPG agents were selling the LPG cylinders accepting the voucher and the date in which the agents were receiving the 16 nuevos soles from the FISE program. This situation discouraged the agents to participate in the program. Many agents sold it with an extra cost for the beneficiary families of the voucher or even refused to accept the vouchers. This situation created discontent among

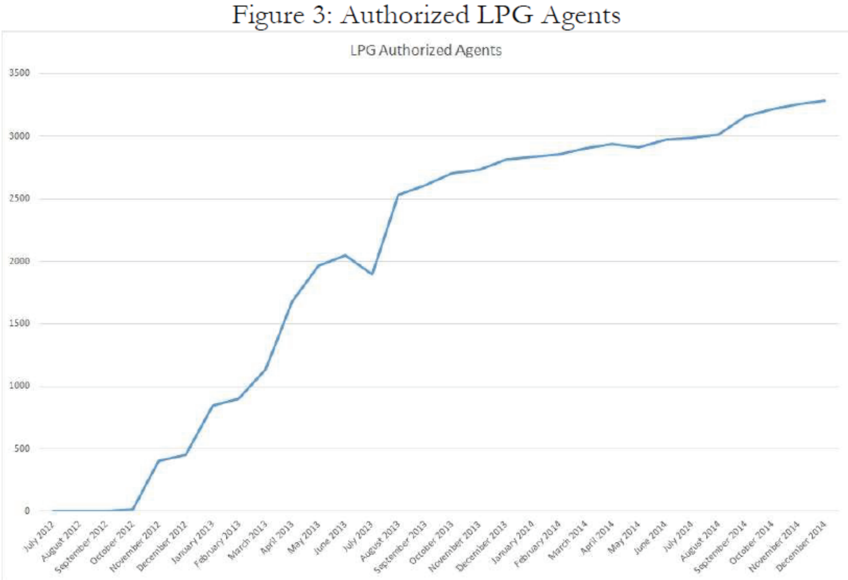
[13] There are two types of Authorized Agents LPG, LPG bottling plants and stores. The bottling plants issue certificates in accordance with their sales representatives and perform the supervision and training of their sales agents. The stores must request the certificate of conformity to bottling plants, then they must apply to OSINERGMIN for registration in the Register of Hydrocarbons, and must sign an agreement with the electricity distributor companies to be an Authorized Agent to exchange the FISE voucher.

[14] The implementation of the digital voucher has received several national and international awards. At the national level, it has been awarded with the Business Creativity Contest organized by the Peruvian University of Applied Sciences (UPC). Internationally, include recognition of the Organization of American States (OAS) and Asia-Pacific Economic Cooperation. In two reports of these organizations it is appreciated the work done by FISE. The OAS noted that the FISE promotes efficiency and represents a breakthrough for achieving environmental, economic and social sustainability. For its part, the APEC recognizes the proper functioning of FISE in his document "Peer review on fossil fuel subsidy Reforms in Peru".

both beneficiaries and LPG suppliers, and led many suppliers to unsubscribe from the program.[15] The digital voucher was created in July 2013 to eliminate these problems and since its introduction the number of suppliers has increased significantly (Figure 3). Currently, digital voucher complements the printed ones.

The digital vouchers allow the LPG suppliers to receive the value of the voucher at the time of the transaction. This has facilitated the diffusion of the project in urban and rural areas, and has also led to an increase in demand. On the other hand, the digital voucher has reduced the administrative costs of the project. It is interesting to note that the use of digital vouchers in Peru is possible because more than 60% of the rural population has a mobile phone. In spite of this, some reports have found that is necessary to train the beneficiaries so they can correctly use the phone.

Figure 3: Authorized LPG Agents



Source: Elaborated by authors from Memoria Anual de Gestión FISE 2012-2013 and 2013-2014

Finally, the electricity distribution companies are responsible for managing the digital voucher.[16] Specifically, they send a code to the beneficiary via

[15]Some LPG agents did not accept vouchers or increased the price of the cylinder to those buyers who used the vouchers. Another problem was that the electricity distributors companies sent the vouchers through the receipts of electricity on open envelopes. This led to some postal employees to collect the codes to redeem vouchers fraudulently.

[16]The cost incurred by these companies to implement the FISE program in their jurisdic-

SMS that can be used to pay the LPG cylinder. When the LPG supplier receives this code it also sends an SMS to the bank with information about the beneficiary and the code, and it receives an immediate transfer. Previously, the bank receives the money from the electricity distributor, and this periodically receives compensation from the FISE administrator.

Each month, the electricity distributor sends to the FISE information about the electricity consumption of the beneficiary. This allows verifying if the beneficiary consumes less than 30 Kwh per month.[17] If the beneficiary consumes more than this amount the FISE communicates to the electricity distributor that it cannot issue the voucher for the next month. The FISE also controls the number of transactions completed by each beneficiary to avoid fraudulent uses of the vouchers. For example, the FISE is able to detect if a beneficiary makes more than 3 exchanges in one month.[18]

3.4 Financial Resources

FISE is financed by three types of surcharges: 1) surcharges of 2.5% on the monthly bill of electricity free users from SEIN (Sistema Eléctrico Interconectado Nacional). Free users[19] are those who have a price that is not regulated and can negotiate contracts directly with electricity utilities; 2) surcharges of $1 per barrel for liquid products derive from hydrocarbon and natural gas transported by pipelines; and 3) surcharge of $ 0.055 per monthly thousand cubic foots to transport natural gas through pipelines. This implies that the agents that contribute more to finance the FISE are large consumers of electricity, large suppliers of derived liquid hydrocarbon and natural gas liquids and large consumers of natural gas.[20]

Figure 4 below shows the FISE financing sources in 2014. In that year, 81.53% of FISE revenues were obtained through the aforementioned surcharges and 18.47% through the contributions of OSINERGMIN. In total $147,228,005

tion is previously approved by OSINERGMIN and are subsequently refunded by the FISE administrator.

[17] On annual average.

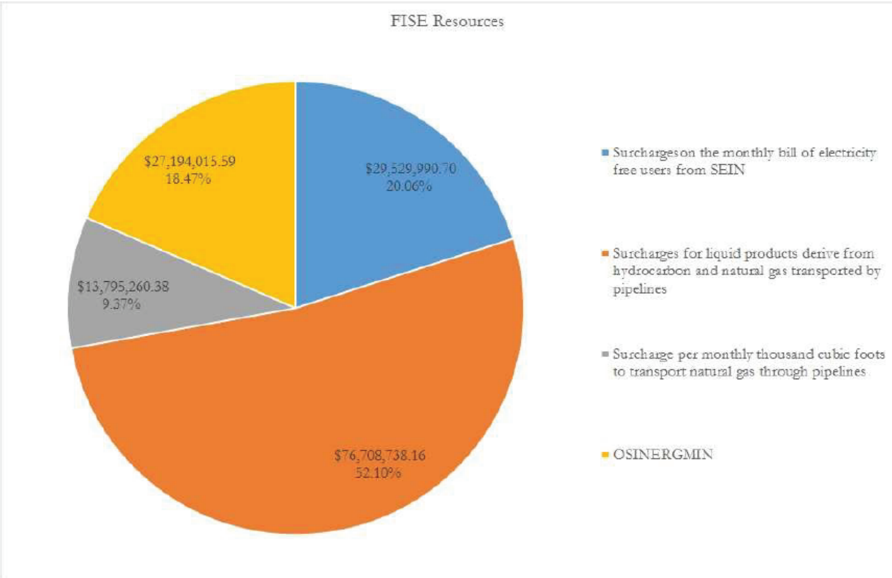
[18] FISE can also know the storage capacity and the number of transactions carried out by the LPG suppliers. This allows FISE to detect fraudulent behaviors.

[19] Free users are those who consumes more than 2500 KWh monthly.

[20] Producers and importers of liquid products derived from hydrocarbons and liquid natural gas are responsible of collecting the FISE surcharge and of transferring it to FISE every month. Similarly, the firms that transport natural gas through pipes collect every month the surcharges and transfer them to FISE.

were raised, 50.36% more than in the previous year. The largest increase was obtained due to pipeline transportation surcharges resulting from liquid hydrocarbons and natural gas, which increased by 311.76%.

Figure 4 FISE Resources



Source: Elaborated by authors from Memoria Anual de Gestión FISE 2012-2013 and 2013-2014

4 Data and methodology

4.1 Database

The main objective of this section is to evaluate the results of FISE program during the first years of its life. To do so, we use a survey conducted by OSINERGMIN in April 2015 in the province of Huamanga, one of the 11 provinces of the Department of Ayacucho.[21] Huamanga has a population of 221,390 inhabitants, 2981.37 km^2, and is divided into 16 districts, one of which is the city of Ayacucho. The average height of this province's villages is 2,500 meters. The survey was conducted on houses located in the following five districts of the province: Andrés Avelino Cáceres, Ayacucho, Carmen Alto,

[21] This research is considered a pilot study. It is important to note the small sample size, that the survey contains no anthropometric measurements of individual respondents and also no actual measurements of pollution inside home.

Socos and Vinchos. The initial objective was to focus the survey on Vinchos, as it was supposed to be representative of the country's reality. In this district, the potential beneficiaries of the program have an exchange rate of the vouchers very close to the national average (60%). Moreover, between the launch of the program until March 2015, the average exchange rate per person was the same as the national average (about 6 vouchers were exchanged per person). However, this district has a higher percentage of beneficiary households and a higher level of poverty than the national average. Currently, 2 out of 3 households in Vinchos are beneficiaries of the program. In spite of this, the survey was later on expanded to other nearby districts in order to increase the size sample and get a suitable control group. The data collected contains information from 458 households in the above mentioned five districts in the province of Huamanga, although most of the households are located in the districts of Vinchos and Ayacucho, 193 and 171 households, respectively. These households correspond to a universe of 1,816 people.

To evaluate the FISE program we use the matching technique, which consists of comparing different outcomes in individuals participating in the program (treatment group) with individuals who have a similar propensity to participate in the program but that actually do not (control group). A potential problem with this technique is that results can be biased if the socio-economic characteristics of the two groups are different. To overcome this problem, initially a random sample of voucher beneficiaries in several districts of the province of Ayacucho was chosen as a treatment group. Subsequently, using information from the SISFOH and FISE database, households that had not applied to participate in the FISE program but had similar characteristics to the treatment group were included in the control group.

Table 1 shows that for some of the variables considered in the survey there are significant differences between the treatment and the control groups. For example, while in the control group 74% of households regularly use the Quechua or Aymara as a communication language in the family, in the treatment group the figure rises to 94% of households. Significant differences in the percentage of households who have migrated to the area are also observed, 11% in the treatment group and 32% in the control group. On the other hand, 64% of household heads in the control group have successfully completed primary education, while the percentage drops to 43% for the treatment group. One explanation for these differences is that at the time of the survey no information was available on household income. Indeed, while the average monthly income of households in the control group is 797 nuevos soles, for the treatment group is 390 nuevos soles. We try to address this situation in our analysis.

In relation to household expenditure on electricity consumption, note that the households in the control group have higher expenses than those in the treatment group. A significant difference in the monthly expenditure on LPG is also observed, which is about 16 nuevos soles ($ 5) monthly, equivalent to the discount voucher offered by the FISE. This result would indicate that the reception of the voucher allows beneficiaries to consume the same amount of LPG than non-beneficiary households. The objective of this section is precisely to determine in which extent the FISE voucher helps beneficiaries to use more LPG than households with similar characteristics which do not receive it.

Table 1 also explains what the uses of LPG stoves are, and what heating systems are used in the households interviewed. In both groups there is a similar percentage of households using only wood as a heating fuel. However, in the control group there is a higher percentage using only modern heating fuels (LPG and electricity). On the other hand, in the treatment group homes are more prone to use a combination of wood and modern heating fuels. Finally, households in the treatment group are those that use more LPG stoves and fewer traditional stoves.

–Insert table 1 here–

Another remarkable aspect of the collected data is that about 67% of households have the perception that LPG stoves reduce the cooking time regarding traditional or improved stoves. This result is confirmed when we analyse the daily cooking time by type of stove. The number of hours per day a household spends in cooking is 2.01 hours if it uses an LPG stove, 2.05 hours if it uses an improved stove, and 2.34 hours if it uses a traditional stove. On the other hand, in 63.59% of the households surveyed, the woman is who decides the type of stove that is purchased by the family.

A potential problem that could arise when choosing treated and untreated households in the same district or in the same province is the existence of spillovers, which arise when a program benefits, indirectly, the control group. For example, the electrification of a village improves the economic conditions of the people accessing electricity, but indirectly it also modifies the socioeconomic situation of people next to them. In the case of LPG stoves we do not believe there is a major problem of spillovers because LPG vouchers only benefit families who use them to cook and that will be less exposed to indoor pollution. On the other hand, we consider unlikely that the program beneficiaries resell the gas cylinders to other people, because the objective of the program is precisely to benefit the poorest households and those with low electricity consumption, and because the FISE program has a tight control of fraud. Also note that the FISE program has been implemented in mostly all the Peruvian municipalities and as a consequence we cannot compare households in treated and in control municipalities to avoid for potential spillovers of the program.

4.2 Measures to evaluate the impact of the program

To assess the effects of the FISE voucher in the habits of the population, we examine the following indicators: 1) ratio of weekly LPG cooked meals; 2) presence of cough or respiratory problems in the household in the last month; 3) number of days children have missed school due to respiratory problems; 4) whether water is boiled or not; 5) use of LPG stoves to boil water; and 6) number of days that children have missed school due to diarrhoea.

The objective of our empirical analysis is to determine whether the use of discounts vouchers increases the use of LPG stoves and reduces the likelihood of having respiratory problems. At first, there should be a direct relationship between the use of LPG stoves and the reduction of pollution inside homes. However, it is important to note that in rural areas of Peru many homes combine the use of LPG stoves with firewood or improved stoves, which can maintain high the pollution level inside the household. For this reason, the main variable that we use in our analysis is the ratio of weekly LPG cooked meals.

To study the effects of FISE voucher on health, we use indicators that reflect the existence of respiratory problems that may be caused by the use of wood (solid fuels) for cooking. Reducing emissions should reduce the probability of finding household's members who have had respiratory problems. The indicators we consider are whether a household's member has had respiratory problems or cough in the last 30 days. In addition, we also consider the number of days that children have missed school due to respiratory problems.

Another objective of the chapter is to analyse the effect of the vouchers in the decision of households to boil water, since boiling water can have a very important role in preventing water related diseases. The use of LPG stoves allows boiling water faster than firewood stoves and may encourage this practice. To assess the impact of the program, we use as an indicator whether the household boils water or not, and if the household boils water using an LPG stove. To determine the effects on health, we also consider the number of days that children have missed school due to diarrhoeal problems.

Table 2 shows the descriptive statistics for each of these outcome indicators, differentiating households between beneficiaries and non-beneficiaries of the FISE voucher. The table shows significant differences in the use of LPG stoves among the two groups. In particular, program beneficiaries cook in average 13% more weekly meals in their LPG stoves than those who are not beneficiaries. Secondly, children in households participating in the program miss school 0.17 days less per month than children of non-beneficiary households because of diarrhoeal problems. For the other variables, we do not find significant differences between the two groups. Despite this, in order to properly compare the two sample groups it is necessary for the two types of households to have similar socioeconomic characteristics. Hereafter we show how the data has been processed to have a proper counterfactual.

−Insert table 2 here−

4.3 Identification strategy and propensity score

To make the matching between households in the control and the treatment group, it has been taken into account the electricity consumption and households' characteristics[22] (e.g. education level of people in the household, house-

[22] Variables used: use of solid fuels for cooking, use of a LPG stove, number of household assets, participation in social programs (SIS, cunamas, P65, together, techo propio), access to electricity, access to drinking water, availability of latrines within home, being in possession of a telephone (fixed or mobile), ratio of overcrowding, materials used in the construction of the house, number of people in the household, presence of children with school backwardness, the presence of over 18 years old adults with elementary education , years of education of the household head, years of education of the spouse of the household head, average years of education of the workers at home, unemployment of all household members, illiteracy of the household head, household head gender and education, age of

hold demographics, participation in other social programs, etc.). With these variables a probit model was estimated to calculate the distribution of the propensity to receive the treatment. In particular, the coefficients of the probit model allow calculating the probability of each household to participate in the program. These propensity scores are then used to find a group of non-beneficiary FISE households that can be appropriately grouped with beneficiary households to analyse the impact of this policy. Thus, households with the same propensity to receive the treatment are compared, but while some receive the voucher, others do not. Finally matching algorithms are used to assign each beneficiary household with households not participating in the program with the closer propensity score.

On the basis of the variables included in the survey, first we carry out a logit analysis to verify that the variables used to create the sample are not significantly different between the control and treatment group.[23] The covariates included in the logit model should affect both the possibility of receiving treatment and the dependent variables we want to study. In particular, the variables used are: number of assets at home, having a telephone (fixed or mobile) at home, access to other social programs, access to water and sanitation within the home, characteristics of the home (if the floor is made of soil, if the walls are of a material other than brick and if the roof is of a material other than concrete), being in possession of an improved and / or traditional stove, electricity monthly expenses, educational levels of the head household and his/ her spouse, if the head household is illiterate, the age and gender of household head, whether at home nobody works, along with a dummy for each district.

Table 3 shows the estimations of the logit model. The Pseudo R2 is quite high, being of 0.4948. In spite of the methodology applied to create the database, we find that some variables are still significant, meaning that there are differences between the treatment and the control group. One explanation for this is that initially the selection of households was conducted with the SISFOH 2013 database, while the survey for this research is from 2015. On the other hand, when conducting the sample, the variable household income was not included, as it was not available. However, at present this information is

household head, districtal dummy, dummy if the home is in a rural nucleus of population and the electricity consumption in the last 12 months. Importantly, the last variable is the one that has a greater weight in the propensity score.

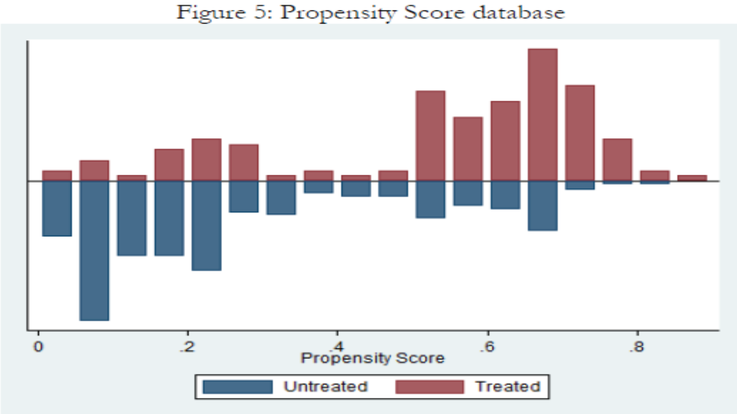
[23]Note that the same logit analysis is performed by quartiles in the subsamples. The results of the different regressions are shown in Table 12.

available and we include it in our matching analysis to avoid biased results.

Afterwards, we calculate the propensity score for the two groups of households, including the variables that were significant in the previous model and the variable on household income.[24] Figure 5 shows the results of the propensity score. It can be noted that the database is not perfectly balanced, since there is a different distribution between the two groups of households. As expected, non-treated households have values of propensity score close to 0 and treated households have values closer to one, due to the criteria for participation in the FISE program. Still, for the whole range of the estimated propensity score, there are enough treated and untreated households that would allow us to calculate the treatment effect from our database.

–Insert table 3 here–

Figure 5: Propensity Score database



5 Results: Nearest neighbour and kernel matching

Taking into account the results of the propensity score, we have applied several matching algorithms to determine the effect of FISE voucher on the outcome indicators. First, we used the "nearest neighbour without replacement" (NN), which uses for each treated household one (or more) households in the control

[24]Due to the high correlation between the variables Vinchos and the variable income, it has been decided not to include the variable Vinchos in the calculation of propensity score or when assessing the effect of the voucher in the different indicators.

group that have the propensity score closest to the propensity score of the treated household within the area of common support. Thus, households as similar to each other as possible are compared. One of the risks of using this method is that it is possible to compare households whose propensity score values are not close enough, and as a result have different characteristics. To ensure the robustness of our results we also present the results using the kernel matching algorithm. In this case, the algorithm selects each of the households in the treated group and compares it with all households in the control group. That is, it compares each of the treated homes with the average of all households in the control group.

We begin our analysis analysing the effects of the FISE voucher on the use of LPG stoves. We note that the participants in the program (households receiving the voucher and potentially an LPG stove) cook 42% more of their weekly meals using an LPG stove compared to other households who do not receive the voucher. On the other hand, when we focus the analysis only on the households owning LPG stoves we observe that the FISE increases the use of LPG stoves about 17% (i.e. 4 weekly meals). Therefore, the program fulfills two objectives: it encourages the replacement of traditional or improved stoves for LPG stoves; and promotes greater use of LPG stoves in homes that already have them.

Table 4: Outcome indicators for sample

Outcome indicator	Estimation	Treatment effect	t-statistic	Observations
Ratio lpg (1)[25]	Nearest neighbour	0.420892*** (-0.0581343)	7.24	351
	Kernel	0.4366407*** (-0.0540036)	8.09	351
Ratio lpg (2)	Nearest neighbour	0.1864173** (-0.0918753)	2.03	267
	Kernel	0.169491* (-0.0881808)	1.92	267
Families boiling water	Nearest neighbour	0.0096096 (0.1261495)	0.5	236
	Kernel	0.1123906 (-0.0950783)	0.1	236
Families boiling water using LPG stove	Nearest neighbour	0.183908 * (-0.1041214)	1.77	178
	Kernel	0.1783419* (-0.1003804)	1.78	178

*** Significant at 1%; ** significant at 5%; * significant at 10% 25

The results above show the effects of the FISE voucher on the whole population. However, an important aspect in the evaluation of the program is to determine which groups of people are the most benefited. To give insight into it, we repeated the previous analysis dividing the sample into quartiles according to household income. Due to the small sample size, we take into account all households in the data, regardless of whether or not they have an LPG stove. Table 5 shows that FISE voucher has a more pronounced effect in households with lower income. In particular, households in the lowest quartile participating in the program cook between 53% and 56% more weekly meals with LPG stoves. This amounts to about 12 weekly meals. In the second quartile, the results indicate that FISE voucher increases the number of weekly meals cooked with LPG stoves in about 20%. However, the results are not significant if we use the nearest neighbour technique. This could be a consequence of the reduced sample size. The results for the third quartile confirm the robustness of the previous results: FISE voucher increases the weekly use

[25]The ratio LPG (1) indicator uses the entire sample whether or not the household has an LPG stove. By contrast, the ratio LPG (2) indicator only takes into account those households with LPG stoves.

of LPG stoves between 35% and 41% (between 7-9 meals per week). Finally, in the top quartile, FISE voucher does not increase the use of LPG stoves.

Table 5: Outcome indicators for the use of stoves by quartiles

Outcome indicator	Estimation	Treatment effect	t-statistic	Observations
Ratio LPG (first quartile)	Nearest neighbour	0.5638779*** (-0.0854935)	6.6	99
	Kernel	0.5338816*** (-0.0791267)	6.75	99
Ratio LPG (second quartile)	Nearest neighbour	0.173082 (-0.1654318)	1.05	80
	Kernel	0.2209391** (0.1090747)	2.03	80
Ratio LPG (third quartile)	Nearest neighbour	0.4107937*** (-0.1225226)	3.35	95
	Kernel	0.3520909*** (-0.1283204)	2.74	95
Ratio LPG (fourth quartile)	Nearest neighbour	0.0018166 (-0.206246)	0.01	79
	Kernel	-0.0455721 (-0.1804395)	0.25	65

*** Significant at 1%; ** significant at 5%; * significant at 10%

The FISE program could help to improve population's health, by promoting people to boil water more often. However, results of Table 4 do not validate this hypothesis. We note that households participating in the program are not more prone to boil water than those not participating and having similar characteristics. These results are maintained when we divide the sample in quartiles (we do not show these results here for simplicity). This situation might reflect that a large part of the population is aware of the importance of boiling water. The 87.5% of the control group and 82.3% of the treatment group do it regularly. However, if we focus on the households that have an LPG stove, we find that an 18% more of households in the treatment group boil water with their LPG stove in comparison with the control group. This result suggest that one of the channels through which the FISE can improve the living conditions of the population is the substitution of the traditional stoves for LPG stoves to boil water. These stoves boil water quickly and use less resources.

An important objective of the FISE program is to reduce the indoor air contamination. It is believed that the substitution of traditional stoves for LPG stoves can moderate the toxic emissions inside the house and reduce respiratory diseases, especially those of women and children, which spend more time at home. In order to contrast this hypothesis we want to contrast if the population benefiting from the program has had less respiratory problems or cough less in the month prior the interview than the households that don't participate in the program. Moreover, we also consider the number of days that the children[26] in the family have missed school due to respiratory problems.

Table 6: Cough and respiratory problems

Outcome indicator	Estimation	Treatment effect	t-statistic	Observations
Cough problems	Nearest neighbour	0.0459318 (-0.1021125)	0.45	327
	Kernel	0.0658858 (-0.0791849)	0.83	327
Respiratory problems	Nearest neighbour	0 (-0.0626632)	0	328
	Kernel	0.0451804 (-0.0465471)	0.97	328

*** Significant at 1%; ** significant at 5%; * significant at 10%

Results in Table 6 do not suggest a relation between program participation and reduction of respiratory problems. Tables 7 and 8 show similar results when the sample is divided into quartiles. A justification for this is that many homes combine the use of LPG stoves with traditional stoves, for economic and / or cultural reasons. Moreover, many households continue to use polluting fuels for heating purposes making that indoor air pollution remains high. The data of the survey was collected in April, which is considered the Fall season in the Sierra region of Peru. In future studies it would be recommendable making

[26] The age of children in the survey who attend school and have been chosen for the analysis goes from 2 to 12 years old.

measurements of intra-domiciliary pollution in different periods of the year to identify more clearly the effects of the program. Finally, another limitation of our analysis is that it considers all the population living in the households, including adults and children of different sex and ages. But the exposure of these groups to intra-house contamination can vary importantly and also the effects of the emissions on them. In this sense, a bigger sample size will allow to obtain more precise estimates of the impact of the program in each population group.

Table 7: Cough problems by quartiles

Outcome indicator	Estimation	Treatment effect	t-statistic	Observations
Quartile 1	Nearest Neighbour	0.1960784 (-0.1311029)	1.5	90
	Kernel	0.158189 (-0.1194387)	1.32	90
Quartile 2	Nearest Neighbour	0.0375 (-0.1425813)	0.26	73
	Kernel	0.0359727 (-0.1084262)	0.33	73
Quartile 3	Nearest Neighbour	-0.0533333 (-0.1977024)	0.27	91
	Kernel	-0.045746 (-0.1932069)	0.24	91
Quartile 4	Nearest Neighbour	0.15 (-0.2554408)	0.59	75
	Kernel	0.2244491 (-0.2346036)	0.96	75

*** Significant at 1%; ** significant at 5%; * significant at 10%

Table 8: Respiratory problems by quartiles

Outcome indicator	Estimation	Treatment effect	t-statistic	Observations
Quartile 1	Nearest Neighbour	0.1764706*** (-0.0700005)	2.52	91
	Kernel	0.0056077 (-0.0966134)	0.06	91
Quartile 2	Nearest Neighbour	0.1 (-0.1143824)	0.87	74
	Kernel	0.0375012 (-0.104129)	0.36	74
Quartile 3	Nearest Neighbour	0.04 (-0.0688186)	0.58	90
	Kernel	0.0652055 (-0.0680554)	0.96	74
Quartile 4	Nearest Neighbour	0 (-0.2)	0	75
	Kernel	0.1269422 (-0.158416)	0.8	75

*** Significant at 1%; ** significant at 5%; * significant at 10%

Additionally, another objective of this chapter is to analyse whether the FISE program has succeeded to improve the health conditions of children. In order to analyse this situation we use as an indicator the number of days that children have missed school due to respiratory problems. Our results do not show that the FISE voucher has an impact in the number of days that households' children missed school.[27]

Table 9: Missing days to school from children due to respiratory problems

Outcome indicator	Estimation	Treatment effect	t-statistic	Observations
Missed school days due to respiratory problems	Nearest neighbour	-0.2037037 (0.1928715)	1.06	118
	Kernel	-0.137384 (0.2380706)	0.58	118

*** Significant at 1%; ** significant at 5%; * significant at 10%

Finally, we also study the impact of FISE program in the prevalence of water related diseases in children attending school. We have already seen that the FISE program increases the possibility that households with an LPG stove

[27]Given all members attending school between 2 and 17 years old, the results did not differ. The results using the nearest neighbour is not very robust (significant at 10%) and is not significant using the Kernel technique. Results at the appendix.

boil water using that stove. This situation might positively affect children's health. Thus, for example, one of the lessons learned during the preparation of the survey was that the families' beneficiaries of the voucher use to boil the water that children bring to school in their LPG stoves. In order to test this hypothesis we use as an indicator the number of days that children have missed school due to diarrhoea episodes.

The estimations in Table 10 show a positive effect of the FISE voucher. The estimator shows that the FISE voucher reduces the days that children do not attend school at least 0.23 monthly days (3 days per year). The channel through which this effect would occur is due to boiling the water that children bring to school.[28]

Table 10: School missing days of children due to diarrheal problems

Outcome indicator	Estimation	Treatment effect	t-statistic	Observations
Missed school days due to diarrhoea problems	Nearest neighbour	-0.2333333 *** (-0.0880656)	2.65	104
	Kernel	0.3183973** (-0.1555894)	2.05	104

*** Significant at 1%; ** significant at 5%; * significant at 10%

6 Conclusions

In this chapter we have described the FISE program implemented in Peru and we have evaluated its effects. The main objective of the FISE program is to provide security to the energy system and to provide universal access to energy for the most vulnerable groups of the society. One of the most important projects of FISE is to facilitate access to LPG as a cooking fuel to the most vulnerable sectors of the population by granting monthly discount vouchers. Since its creation in 2012 more than one million households have benefited from this project. Nowadays, FISE operates in 100% of the regions of Peru and 92.6% of the country's districts. This policy of promoting LPG stoves through discount vouchers is unique in Latin America and has received

[28] Given all members attending school between 2 and 17 years old, the results are similar. The reception of the voucher reduces by about 0.24 days the days children do not attend school. Results in the appendix.

recognition from various international organizations.

One of the most remarkable characteristics of the FISE program is that it is financed largely through surcharges on large energy consumers and suppliers in Peru. In particular, in 2014 about 82% of FISE resources came from surcharges on the monthly bill for electricity free users of interconnected systems, the surcharges for liquid products derived from hydrocarbon and natural gas transported through pipelines and surcharges to the transport of natural gas through pipelines. Other revenues come from transfers of OSINERGMIN, the energy regulator.

FISE has made a major effort to focus its efforts on low-income households, avoiding many of the problems that have arisen in other developing countries when it comes to promoting LPG as cooking fuel, where studies show that subsidies fell on the most advantaged population. Moreover, the creation of the digital discount vouchers has attracted a large number of LPG suppliers to the program and eliminated various management problems that emerged during the first months of the program. Moreover, the FISE has enhanced the market of LPG in Peru, easing the access to this type of fuel for the entire population.

The second part of the chapter has evaluated the effects of the FISE vouchers in a set of outcomes. By using a data set collected by OSINERGMIN in 2015 we have found that the reception of the FISE voucher increases the number of meals cooked weekly with LPG in 9 meals. This value can increase up to 12 meals per week in the case of the poorest households. Thus, it is shown that the program has succeeded in increasing the use of LPG as cooking fuel and also achieved a higher impact on lower-income strata of society. However, to date there has not been a complete replacement of traditional stoves and improved ones by LPG stoves. This fact, jointly with the majority of households using wood as heating fuel makes difficult the reduction in indoor air pollution and therefore a reduction in the prevalence of respiratory diseases. Our analysis finds no direct link between the reception of the voucher and a reduction in cough or respiratory problems in beneficiary households. Moreover, the reception of the voucher does not seem to reduce the number of days that children miss school due to respiratory problems.

One of the most interesting results of our analysis is that the FISE voucher facilitates the replacement of traditional or improved stoves for LPG stoves to boil water. One explanation for this is that less time and resources are required to boil water with LPG stoves than with traditional stoves. Moreover, our analysis has also found that children from households receiving the voucher miss less days of school than children of non-beneficiary households due to diarrhoea.

The results of our work can be useful in guiding energy policies in developing countries where major health problems arise from the use of polluting fuels for cooking and heating. Our analysis shows that the use of a voucher can be an effective mechanism to promote the use of LPG as cooking fuel. Actually, one of the problems of subsidizing the price of LPG is that it reduces the price of this product and favours high income households, as they are the ones that consume more LPG. The voucher, being focused on the poorest households, does not imply a redistribution of income from government to the rich households.

However, our results show that this policy by itself cannot be effective in reducing respiratory problems of the beneficiary households. Indeed, a significant part of the beneficiaries' households combine the use of traditional stoves with LPG stoves. On the other hand, it is very common to burn solid fuels inside the house for heating. Thus, an effective policy for reducing pollution requires increasing the size of the subsidy and should be complemented with other energy efficiency measures.

7 Appendix

Table 1 Households' socioeconomic characteristics

Variable	Total	FISE Beneficiaries	FISE Non-Beneficiaries	|t|
Household variables				
Household size	3.973626	3.927374	4.003623	0.4376
Members at meal time	3.621978	3.642458	3.608696	0.2136
Members working	1.677704	1.575419	1.744526	1.6173
Access to social programs	49.89%	76.88%	32.20%	10.133
Monthly Income	645.5307 Soles (201.22$)	390.9075 Soles (121.85$)	797.2653 Soles (248.52$)	5.9425
Monthly electricity expenses	22.26697 Soles (6.95$)	13.61445 Soles (4.24$)	27.8316 Soles (8.67$)	5.3374
Monthly LPG expenses	25.50552 Soles (7.95$)	18.64356 Soles (5.81$)	34.16875 Soles (10.65$)	14.9894
Woman as Head's Household	21.90%	24.02%	20.51%	0.8811
Age of Head's Household	45.96341	46.87578	45.37349	0.9761
Head's household Education: Primary	55.88%	43.43%	64.04%	4.35
Spouse Education: Primary	44.85%	30.00%	54.50%	4.4914
Head's Household : Illiteracy	16.06%	20.00%	13.48%	1.8275
Ethnic group	81.68%	93.79%	73.91%	5.4983
Migration	22.37%	10.95%	32.28%	4.519
Housing variables				
Roof: Concrete	23.91%	6.88%	33.82%	6.6548
Walls: Brick	23.18%	5.11%	34.66%	7.7098
Floor: Soil	67.86%	86.05%	56.52%	6.8237
Phone (fix / Mobile)	44.50%	31.93%	52.49%	4.2454
LPG stove	79.17%	94.41%	69.31%	6.7449
Improved stove	26.32%	40.78%	16.97%	5.8341
Traditional Stove	49.78%	45.25%	52.71%	1.5557
Heating				
Only Wood	40.07%	40.44%	39.75%	0.1204
Only Modern Fuels	20.81%	13.14%	27.33%	3.0441
Wood and Modern Fuels	37.04%	45.59%	29.81%	2.8331
(Only) Electricity	26.26%	19.12%	32.30%	2.5921

Table 2: Descriptive statistics of potential outcome indicators

	Total	FISE Beneficiaries	FISE Non-Beneficiaries	Dif	t
Proportion of weekly meals cooked with LPG	0.632284	0.7104067	0.580298		
	(-0.4080866)	(-0.3225974(	(-0.4492776)	0.1301***	3.5851
	N=453	N=181	N= 272		
Families with a member with cough problems	0.4783654	0.4795322	0.477551		
	(-0.5001332)	(-0.5010481)	(-0.5005183)	0.0019	0.0397
	N=416	N=171	N=245		
Families with a member with respiratory problems	0.1547619	0.1520468	0.156625		
	(-0.3621089)	(-0.3601208)	(-0.3641803)	-0.0045	0.1272
	N=420	N=171	N=249		
Missed school days due to respiratory problems	0.4	0.2666667 (0.1254746)	0.5142857		
	-0.0806947	N=60	-0.1032452	-0.247619	1.5378
	N=130		N=70		
Families Boiling water	0.8621444	0.8333333	0.8808664		
	(-0.3451261)	(-0.3737175)	(-0.3245319)	-0.047	1.398
	N=457	N=180	N=277		
Missed school days due to diarrheal problems	0.1652174	0.0740741	0.2459016		
	(-0.0477254)	(-0.0582283)	(-0.0726386)	-0.1718276 *	1.8148
	N=115	N=54	N=61		

Table 3: Probability of receiving the voucher according to the variables selected to create the sample. Logit model

Covariates	Coef.	Std. Err.	z
Number of assets	0.3754544*	0.2086363	1.8
Telephone	-0.2033043	0.4008617	-0.51
Social Programs	0.9374904**	0.4338963	2.16
Water inside home	-0.1197858	0.4946597	-0.24
Latrines inside home	-0.2586807	0.5355323	-0.48
Floor: Soil	-0.168781	0.6310209	-0.27
Walls: no brick	2.186193*	1.297188	1.69
Roof: no concrete	-1.34455	1.254084	-1.07
Improved stove	-0.7781464	0.5991428	-1.3
Traditional stove	-1.295959**	0.542058	-2.39
Electricity monthly expenses	0.0009491	0.0087091	0.11
H. Head: Primary Ed.	1.128722**	0.5345734	2.11
H. Head: Secondary Ed.	0.0562102	0.6055719	0.09
H. Head: Higher Ed.	-0.5158354	1.078565	-0.48
H. Head: Gender	0.1196766	0.7370068	0.16
H. Head: Age	0.0185778	0.0162801	1.14
Spouse: Primary Ed.	0.1956599	0.8180267	0.24
Spouse: Secondary Ed	-0.2167094	0.9998586	-0.22
H. Head: Illiteracy	0.0765582	0.6102327	0.13
Spouse: Without Education	0.4042993	0.7203023	0.56
No workers at home	0.4317615	0.9368456	0.46
Vinchos	4.097278***	0.6294202	6.51
Andres	0.9660671	1.26551	0.76
Carmen Alto	-0.59402	1.235215	-0.48
Socos	0.4095248	0.8785955	0.47
_cons	-4.811994	1.618512	-2.97

*** Significant at 1%; ** significant at 5%; * significant at 10%

Table 11: Logit for the sample of households with LPG cooking

Var.	Coef.	Std. Err.
Number of assets	.5249631*	0.2985915
Telephone	-1.020837*	0.5850285
Social programs	1.079476*	0.6347733
Water inside home	0.0383169	0.7938815
Latrine inside home	-0.7202033	0.7684411
Floor: Soil	-1.186694	0.8656388
Walls: No brick	2.344699*	1.336555
Roof: No concrete	-0.1974505	1.316994
Improved stove	-0.0065343	0.7914977
Traditional stove	-0.2744241	0.6592975
Electricity monthly expenses	0.0075988	0.0088002
H. Head: Ed Primary	1.569353*	0.891957
H. Head: Ed Secondary	-0.4195864	0.910116
H. Head: Higher Education	-1.326288	1.313432
H. Head: Gender	-1.336501	1.00627
H. Head: Age	-0.0055544	0.0251753
Spouse: Ed Primary	-0.7567331	1.05986
Spouse: Ed Secondary	0.1281161	1.322667
H. Head: Illiteracy	2.407592*	1.28776
Spouse: No Education	-0.1180952	0.9675534
Non-working members (household)	4.235753*	2.347155
Vinchos	5.269665***	0.9570976
Andres	1.652889	1.343142
Carmen Alto	-0.8507736	1.297014
Socos	1.321112	1.181748
_cons	-4.20932	2.082359
N	240	
R^2	0.6684	

Table 12: Logit for the reception of the voucher by quartiles

VOUCHER	Quartile 1		Quartile 2		Quartile 3		Quartile 4	
	Coef	Std. Err	Coef	Std. Err	Coef	Std. Err	Coef	Std. Err
Number of assets	0.4016855	1.854373	0.2368981	0.5704041	1.965222	1.268512	-0.1258695	0.4691795
Telephone	5.979944	4.368245	0.7508946	1.237326	0.8973616	1.623905	-2.746149*	1.454034
Social Program	-1.461967	3.107628	-0.5839581	1.384416	3.443064*	1.836566	1.130867	2.095726
Water inside home	-0.7859476	2.178303	1.024964	1.382358	-0.0825906	1.633449	-2.364625	2.414132
Latrine inside home	-6.512149**	3.014447	1.739773	2.073369	0.5093482	2.630217	-1.876401	2.502182
Floor: Soil	0.7653161	19.26419	0.6867368	1.674045	0.7217124	1.455458	-0.2848099	1.874497
Improved stove	-15.11177**	6.339461	0.2685495	1.869107	n.d.	n.d.	n.d.	n.d.
Traditional stove	-16.08962**	6.763418	-2.577778	2.058317	-1.186356	1.644095	0.3163389	1.451527
Monthly expenses electricity	-0.2423185	0.1644428	-0.0412816	0.0594463	-0.1699869	0.1048325	0.0207046	0.0161721
H. Head Ed Primary	14.19838**	6.802195	0.7823917	1.496143	0.3663337	1.725028	n.d.	n.d.
H. Head Ed Secondary	4.210511	5.004801	-0.2617045	1.709575	n.d.	n.d.	-1.221869	1.58853
H. Head Gender	22.56864**	9.86343	-0.3283138	1.86297	n.d.	n.d.	-0.3915136	2.382025
H. Head Age	.4775806***	0.1806877	.0912561*	0.0489029	0.059345	0.0636359	0.0319151	0.0708869
Spouse: Ed Primary	26.63615**	11.35836	1.969579	2.93126	-1.468626	1.561512	n.d.	n.d.
H. Head Illiteracy	1.754201	2.148353	0.6688235	1.438195	n.d.	n.d.	n.d.	n.d.
Spouse: No Education	19.903**	9.313192	-0.5102928	1.954852	n.d.	n.d.	n.d.	n.d.
No working members	6.367458	5.467454	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Vinchos	24.13768**	10.62692	5.872321***	1.789035	5.590265***	2.178781	n.d.	n.d.
Spouse: Ed Secondary	n.d.	n.d.	1.172528	4.825815	n.d.	n.d.	2.13865	1.698689
Ayacucho	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.302371	1.489656
Walls: no brick	n.d.	n.d.	10.58617	1777.367	0.2436827	1.919145	2.977688	2.305731
Roof: no concrete	n.d.	n.d.	-9.025742	1777.368	n.d.	n.d.	-2.350015	2.621988
_cons	-46.68652	25.99269	-9.467663	5.219296	-9.84357	5.332452	-1.158292	3.286744
N	63		68		68		66	
Pseudo R2	0.7627		0.5966		0.7115		0.3919	

*** Significant at 1%; ** significant at 5%; * significant at 10

Table 13: Missing days from school of children (2-17 years old) due to respiratory problems

Outcome indicator	Estimation	Treatment effect	t-statistic	Observations
Missed school days due to respiratory problems	Nearest neighbour	-0.2435897* (-0.03587041)	1.65	172
	Kernel	-0.175418 (0.181638)	0.97	172

*** Significant at 1%; ** significant at 5%; * significant at 10%

Table 14: Missing days from school of children (2-17 years old) due to diarrheal problems

Outcome indicator	Estimation	Treatment effect	t-statistic	Observations
Missed school days due to diarrheal problems	Nearest neighbour	-0.2384259 *** (-0.0748818)	3.18	155
	Kernel	0.2400228** (-0.1296772)	1.85	155

*** Significant at 1%; ** significant at 5%; * significant at 10%

Table 15: Fuels used for heating

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Only wood	48.50%	58.66%	30.78%	21.74%
Only LPG	1.51%	4.01%	13.46%	21.74%
Only Electricity	0%	1.33%	0%	15.22%
Electricity and LPG	7.57%	6.67%	7.69%	13.04%
Wood and Modern Fuels	42.42%	29.33%	48.07%	28.26%

Table 16 Types of stoves at home

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Only LPG	13.89%	18.89%	33.33%	44.44%
Only Improved	9.26%	11.11%	4.76%	1.11%
Only Traditional	24.07%	12.22%	8.57%	4.44%
LPG and Improved	17.59%	23.33%	13.33%	5.56%
LPG and Traditional	29.63%	34.44%	34.29%	42.22%
Traditional an Improved	0.93%	0%	0%	0%
All three types	3.70%	0%	5.71%	1.11%
It does not cook	0.93%	0%	0%	1.12%

Table 17. Proportion of weekly meals cooked in LPG stoves

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
0 - 25%	40%	24.69%	15.15%	3.80%
26% - 50%	11.43%	14.81%	13.13%	7.61%
51% - 75%	11.43%	12.35%	17.17%	13.93%
76% - 100%	36.19%	48.12%	54.54%	74.69%

Table 18. Proportion of weekly meals cooked in LPG stoves (households with LPG stove)

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
0% - 25%	8.70%	4.69%	5.61%	0%
25% - 50%	17.39%	18.76%	14.61%	7.91%
50 – 75%	17.39%	15.64%	19.09%	14.48%
75% - 100%	56.53%	60.93%	60.66%	77.64%

Chapter V: Conclusions

Access to water and energy services is essential for improving the health and the quality of life of the population living in developing countries. The importance of these services was recently pointed out by the United Nations when it established the Sustainable Development Goals for the eradication of the poverty.[1] Unfortunately, only 1 out of 3 people living in rural areas worldwide rely on piped water and also more than 1.2 billion of rural population still use pollutant contaminants as cooking fuel. The aim of this thesis has been to analyse different policies that can improve the access to these services in rural areas of developing countries. In particular, this thesis contributes to the theoretical and empirical literature analysing the provision of public services in developing countries. In this sense, Chapters II and III have analysed different regulations that can increase the coverage of safe water in rural areas, and Chapter IV has evaluated the FISE program created in Peru for promoting the use of LPG as a fuel for cooking.

Chapter II proposes a theoretical model aimed at analysing the strategic reaction of water utilities facing the competition of a group of water vendors. Previous literature has not considered the effects of competition and regulation on the product line of water utilities and on their investment plans. This chapter explains the optimal strategy of water utilities in this scenario and analyses how the regulation of prices can increase social welfare in both urban and rural areas.

Communal water organizations are a prevalent provision system in Latin American and Peru, but in spite of their relevance they have received very little attention in the literature. Chapter III uses data from the ENDES survey in Peru to evaluate the performance of the Juntas Administradoras de Servicios de Saneamiento (JASS), that are communal organizations in which the Peruvian government has delegated the provision of water services in the rural areas. In addition, the chapter analyses the main factors that can influence the creation of this type of organization.

Finally, using a database created by OSINERGMIN, the national regulatory agency of the energy sector in Peru, Chapter IV analyses the FISE program developed in 2012 to promote the use of LPG cook stoves. The program consists in delivering discount vouchers to the poor households of the country for the purchase of LPG cylinders, and therefore it does not have a direct effect

[1] https://sustainabledevelopment.un.org/topics

in the price paid by medium or high income households. In the Chapter it is applied the matching methodology to evaluate the impact of this program in the cooking habits of the population and in different indirect measurements of the population health.

Next we summarize the main findings of each chapter, and we discuss their policy implications. In addition, for each chapter we present different research lines that could be explored in the future.

1 The regulation of water provision in developing countries

Chapter II develops a theoretical model that shows how the presence of water vendors can alter importantly the decision of water utilities to expand piped water and the mix of technologies used to deliver the service. In the first part of the chapter we consider the case of an unregulated water utility. We show that in order to fight against vendors, the utility can offer both indoor connections and standpipes with different quality levels. On the other hand, the profitability of the utility in each village determines its coverage level.

The model shows that the presence of water vendors has a positive effect in the consumer's surplus in the attended villages. This is because the utility releases standpipes to fight against vendors. As a consequence, in each attended village there is more population with access to the service. In addition, the utility reduces the price of the water served through indoor connections. Moreover, we also show that there is a group of population that gains access to the service thanks to the existence of water vendors. To summarize our findings, we identify the existence of the following trade-off: the existence of water vendors favours consumers in the villages covered by the utility because a large number of low income consumers can access the service and consumers pay lower prices. However, the presence of vendors reduces the utility's revenues and as a consequence it reduces its coverage. Any policy aimed to increase access in urban areas should take into account its effects into the coverage of indoor connections.

The second part of the chapter considers the case in which the water utility is regulated. The imposition of a universal service obligation for standpipes can alter the optimal decision of the utility in relation to the coverage of piped water. Specifically, if the utility is forced to connect all the country with standpipes its optimal decision is to reduce the coverage of indoor connections. This situation is due to the fact that in some villages it is more profitable to offer only standpipes to all population instead of offering both services. This result highlights the presence of another important trade-off between the number of villages with standpipes access and the number of villages with access to indoor connections. This trade-off can be mitigated by reducing the price of standpipes' water in rural areas, since this policy increases the profitability of indoor connections. On the other hand, the regulations that reduce the price of indoor connections make this service less profitable and reduce the coverage of the service. In this scenario, subscribers to piped water pay less for the service, but a larger group of consumers are left without indoor connections. So, another trade-off arises when the water utility is regulated: a low price of indoor connections in urban areas benefits consumers in this area and makes more consumers to switch from water vendors to indoor connections. But when this happens the utility reduces its coverage, which harms a part of the consumers of the rural areas. Thus, regulators should take into account that universal service obligations can alter the optimal decision of the utility when deciding the coverage of piped water.

Finally, the last part of the chapter considers the case in which the regulator decides to split the management of indoor connections and standpipes to avoid the degradation in the quality of standpipes. We assume the case in which the utility is in charge of managing the water indoor connections and there is another firm managing standpipes in all the country. Our results show that the horizontal separation of the utility reduces the coverage of indoor connections, due to the reduction of revenues coming from standpipes. This situation can be mitigated (or worsen) if the regulator sets a uniform price for standpipes throughout the country. Specifically, coverage of standpipes is higher if the costs of expanding pipes are high, and it is smaller if they are low. When the costs of expanding pipes are high, the two firms compete in a few villages, so the imposition of a uniform price forces the standpipes' providers to increase the price and to set it closer to the monopoly price. This situation incentives a significant group of consumers to shift from standpipes to indoor connections, increasing the profits of the utility and its coverage. On the contrary, when the costs of expanding pipes are low, the utility competes in a large number of villages, so the imposition of a uniform price forces the standpipes' providers to set a price close to the competition price in the duopoly area. As a result, the utility's profits are smaller in the urban villages and it chooses a smaller coverage.

To sum up, our findings can be useful to orientate water policies in developing countries. The existence of water vendors can alter the optimal decision of local water utilities, so regulators should analyse carefully this scenario when they design their policies. Also regulators face several trade-offs when trying to achieve universal access. Increasing access with standpipes throughout the country can benefit the population in rural areas but, on the contrary, it can harm the urban population. That is, this policy will increase the population in the country with access to standpipes but it can reduce the population with access to indoor connections because the utility reduces its coverage. In this scenario, price regulation could incentive the utility to increase its coverage. Finally, the decision of supplying indoor connections and standpipes through two independent firms can also reduce the population with access to indoor connections. This situation can be mitigated if the regulator forces the firm managing standpipes to fix a uniform price in all the country but, as we have shown, it is important for the regulator to know the extent of the costs of expanding pipes. If costs are too low, this policy could reduce indoor coverage. Our results can help the policy guide of regulators in developing countries in order to improve the access to a good quality service in their countries.

Also, it is important to note that rural population in developing countries has limited resources to pay for the service. Future research should take this problem into account. In this sense, our theoretical model could be extended to consider that the households' willingness to pay is different in urban and rural areas. This analysis will be useful to better orientate universal access policies in this sector.

2 Community managed water systems: the case of Peru

Peru is a country that has benefited from an important growth in last years, but a large number of the communities living in rural areas still face severe problems to access safe drinking water and clean energy sources. In the case of water services, despite the efforts made in the last decades, piped water coverage in rural areas is significantly lower than in other countries of the region. Since the nineties, the regulation of the water sector in Peru has undergone a major change. On the one hand, there has been an important decentralization process to give more responsibility to the regional and local municipalities for managing and supervising the provision of the service. On the other hand, the government has established a clear separation in the regulation of urban and rural areas, and has promoted the participation of rural communities in the expansion and management of the water systems. In urban areas the service is usually provided by large public firms that are under the responsibility of local and regional governments and supervised by SUNASS, the national water regulatory agency. In the rural communities of less than 2,000 inhabitants the service is usually provided by communal organizations that are called Juntas Administradoras de Servicios de Saneamiento (JASS), which are supervised by local governments. In many communities, however, the provision of the service is not organized by any communal or public water system, and people need to collect water from streams, lakes, or other sources.

Chapter III has shown that communal organizations have an important presence in Latin American countries. It has also described the main reforms in the water sector undertaken in Peru in the last years. The second part of the paper explains that the presence of JASS in a local community is related to its ethnic and socioeconomic characteristics. Communal water organizations are more prone in municipalities with a large percentage of the ethnic group of Quechuas and in areas where the Inca settlements used to be. The JASS also tend to be the provision system in municipalities with fewer technical and professional resources capable of operating the service and, due to the regulatory changes introduced in the 1990s and 2000s, they are also prevalent in the rural areas of each municipalities (i.e. rural population units).

Moreover, it seems that the JASS do not appear to perform significantly worse than the public systems. First, fees charged by them are lower than those set by public firms or local governments, which facilitates the access to water. As a downside, the fees charged by the JASS do not always cover the costs of operation and maintenance of water systems, and in some instances these infrastructures get deteriorated. Second, although access to piped water is less common in the JASS, the quality of the water service does not seem to suffer significantly. Communal systems offer more uninterrupted service and the storage of water is lower than in the case of households served by public operators and local governments. Thus, the JASS seem to be compensating their lack of financial and technical resources with the volunteer work of their members, their higher incentives to provide safe water and their higher knowledge of the needs of the community.

The analysis of the Peruvian experience suggests that despite the limitations of the communal organizations, they might be a cost-effective way to provide water services in rural regions of developing countries. This finding suggests that regulators should give support to these institutions to promote the access to water services. It is important to note that the performance of the JASS depends crucially on the training received by their members. Bearing this in mind, regulators should promote the creation of specialised agencies to train and give technical support to the JASS members. Without appropriate training, community members will not know how to treat the water and maintain the infrastructures, so the system could deteriorate or collapse. On the other hand, it is important to notice that one important factor for the success of this type of organizations is that they know the needs of their communities. In this regard, any policy aimed to provide water to rural communities or to improve the quality of the service needs the involvement of the local communities.

Finally, future research should analyse the governance problems and the performance of communal organizations. It is important not only to know which are the results of these organizations in short but also in long term once the boarding members rotate. Thus, for example, it will be interesting to know how the technical and the economic knowledge is transmitted between boards. If knowledge is not conveniently transmitted it is expected that in the medium term this systems will be degraded and consumers might look for alternative water sources. Taking this into account, water regulators might be needed to assist the JASS when there are changes in the management board. Finally, it will be very interesting to analyse how this type of organizations internally operate in order to know their governance problems.

3 LPG Cook stoves in Peru: Evaluation of the FISE Program

In 2012 the Government of Peru created the "Fondo de Inclusión Social Energético" (FISE), which promotes the access to clean energy to the most vulnerable population and reduces energy inequality in the country. In order to reduce the use of biomass as cooking fuel, the FISE uses two types of economic measures: the free delivery of LPG cook stoves and the concessions of monthly vouchers for the purchase of LPG cylinders to poor households. As far as we know, these policies have not been applied in other Latin American countries.

Chapter IV has described the main characteristics of the FISE program and has evaluated its results. Since its creation in 2012 more than one million households have benefited from this program. Nowadays, the FISE operates in 100% of the regions of Peru and 92.6% of the country's districts. In this chapter we have used a data set created by OSINERGMIN that collects information about the application of the program in five Peruvian districts. Our analysis has shown that targeting the poor population can efficiently increase the use of LPG stoves for cooking purposes. The reception of the FISE voucher increases the number of meals cooked weekly with LPG stoves in 9 meals. This value can increase up to 12 meals per week in the case of the poorest households. Thus, it is shown that the program has succeeded in increasing the use of LPG as cooking fuel and also achieved a higher impact on the lower-income strata of society. In spite of this, the program has not been able to force the complete replacement of traditional stoves for LPG ones.

In terms of health, our analysis finds no direct link between the reception of the voucher and a reduction in cough or respiratory problems. Moreover, the reception of the voucher does not seem to reduce the number of days that children miss school due to respiratory problems. These results could be due to the fact that poor households continue using traditional stoves but also because they use biomass for heating purposes. Taking this into account, our policy recommendation to improve the quality of life of the poor population is to incentive the total substitution of pollutant fuels by cleaner ones inside the homes. In this sense, it is important to reduce the price of LPG, but also to improve the access to clean and cheap energies for heating purposes, for example, enabling poor populations to get access to electricity in their homes.

One of the most interesting results of this chapter is that the FISE voucher facilitates the substitution of traditional or improved stoves for LPG ones to boil water. One explanation for this is that less time and resources are required to boil water with LPG stoves than with traditional ones. Our analysis has also found that children from households receiving the voucher miss less days of school than children of non-beneficiary households due to diarrhoea potentially caused by the poor quality of the water.

The results of this research can be useful in guiding energy policies in developing countries where major health problems arise from the use of polluting fuels for cooking and heating. Our analysis shows that the use of vouchers can be an effective mechanism to promote the use of LPG as cooking fuel, because they allow focusing the intervention in poor households. In some developing countries governments subsidize the price of LPG as a way to increase its use. Unfortunately literature has shown that this is a regressive policy, because high income households are those that make a more intensive use of this energy. In the case of the FISE program, as the voucher is only delivered to the poorest households, it does not imply a redistribution of income to the richest households.

Future research should consider extending this analysis at the national level to obtain a representative sample and get a more accurate view of the effects of the program. Moreover it will be important to get measurements of the indoor contamination. In this sense, our study could be considered as a first step to further analysis.

Finally, taking into account that the use of LPG stoves reduces the time spent collecting fuel and cooking, it will be interesting to analyse if the FISE program improves the quality of life of poor households thanks to the time that can be used to carry out other productive activities. Moreover, it also will be interesting to analyse if the program has improved the education level of children in the households that use the vouchers.

References

[1] Akpalu, W., I. Dasmani, and P.B. Aglobitse. (2011). "Demand for cooking fuels in a developing country: To what extent do taste and preferences matter?" *Energy Policy* 39 (10):6525-6531.

[2] Alcazar, L., Nakasone, E., Torero, M., (2008). "Learning from an incomplete electricity privatization process in rural Peru (Chapter: 7)". In: Chong, A. (Ed.), Privatization for the Public Good? *Inter-American Development Bank*, Washington, D. C., pp. 163e203.

[3] Alesina, A. and E. La Ferrara (2000), "Participation in Heterogenous Communities", *Quarterly Journal of Economics*, 115 (3), 847-904.

[4] Alesina, A., & Zhuravskaya, E. (2008). "Segregation and the quality of government in a cross-section of countries" (No. w14316). *National Bureau of Economic Research.*

[5] Alesina, A., S. Michalopoulos and E. Papaioannou (2012), "Ethnic Inequality", *NBER Working Paper* No. 18512.

[6] Anandalingam, G., S.Y. Wu and P.Y. Chen (2003). "Fighting information good piracy with versioning". *Mimeo*

[7] Andadari, R.K, P. Mulder, and P. Rietveld. (2014). "Energy poverty reduction by fuel switching. Impact evaluation of the LPG conversion program in Indonesia." *Energy Policy* 66:436-449.

[8] Anderson, E. and J. Dana (2009) "When is price discrimination profitable?", *Management Science*, Vol. 55, 6, 980-989

[9] Armstrong, M. (2001), "Access Pricing, Bypass and Universal Service", *American Economic Review*, Papers and Proceedings, 91, 297-301.

[10] Anton, J., J. Vander Weide and N. Vettas (1998), "Strategic Pricing and Entry under Universal Service and Cross-Market Pricing Constraints", *International Journal of Industrial Organization*, 20, 611-629.

[11] Arana Ysa, V., R. Gómez-García Palao and C. Higa Tamashiro (2013), "Abastecimiento de Agua Potable y Saneamiento: Desafíos y Oportunidades en el Perú y América Latina". *Corporación Andina de Fomento.*

[12] Arnold, J., E. Michael, G. Köhlin, and R. Persson. (2006). "Woodfuels, livelihoods, and policy interventions: Changing Perspectives." *World Development* 34 (3):596-611.

[13] Arthur, M. F. S. R., S. Zahran, and G. Bucini. (2010). "On the adoption of electricity as a domestic source by Mozambican households." *Energy Policy* 38 (11):7235-7249.

[14] Arze del Granado, F.J., D. Coady, and R. Gillingham. (2012). "The Unequal Benefits of Fuel Subsidies: A Review of Evidence for Developing Countries." *World Development* 40 (11):2234-2248.

[15] Asaduzzaman, Mohammad, Douglas F. Barnes, and Shahidur R. Khandker. (2010) "Restoring balance: Bangladesh's rural energy realities". *World Bank Publications*, Vol. 181.

[16] Azam, P.J., Dia, M., Guessan, N.T., (2002). "Telecommunications Sector Reforms in Senegal", *World Bank Policy Research Working Paper* 2894.

[17] Bakalian, A. and W. Wakeman (2009), "Post-Construction Support and Sustainabiilty in Community-Managed Rural Water Supply", *World Bank*- Netherlands Water Partnership, Water Sector Board Discussion Paper Series, 48731.

[18] Bakker, K., (2007). "Trickle down? Private Sector Participation and the pro-poor water supply debate in Jakarta", Indonesia. *Geoforum* 38, 855-868.

[19] Bakker, K., M. Kooy, N.E. Shofiani and E.J. Martijn (2008), "Governance failure: rethinking the institutional dimensions of urban water supply to poor households." *World Development*, 36(10), 1891–1915.

[20] Banerjee, A., & Somanathan, R. (2007). "The political economy of public goods: Some evidence from India." *Journal of development Economics*, 82(2), 287-314.

[21] Banerjee, A., L. Iyer, and R. Somanathan (2008), "Public Action for Public Goods", in *Handbook of Development Economics*, Elsevier B.V.

[22] Bansal, M., R.P. Saini, and D.K. Khatod. (2013). "Development of cooking sector in rural areas in India—A review." *Renewable and Sustainable Energy Reviews* 17:44-53.

[23] Bardhan, P., & Mookherjee, D. (2005). “Decentralizing antipoverty program delivery in developing countries”. *Journal of public economics*, 89(4), 675-704.

[24] Barnes, Douglas F., and Liu Qian. (1992) “Urban Interfuel Substitution, Energy Use, and Equity in Developing Countries”. No. 53.

[25] Barnes, Douglas F., Kerry Krutilla, Hyde William F., (2005). “The Urban Household Energy Transition: Social and Environmental Impacts in the Developing World”. Resources for the Future.

[26] Bayliss, K. (2002), “Privatization and poverty: The distributional impact of utility privatization.” *Annals of Public and Cooperative Economics*, 73 (4), 603-625

[27] Bazilian, M., Nussbaumer, P., Eibs-Singer, C., Brew-Hammond, A., Modi, V., Sovacool, B., Ramana, V. and Aqrawi, P. K. (2012). Improving access to modern energy services: insights from case studies. *The Electricity Journal*, 25(1), 93-114.

[28] Behrman, Jere R., and Barbara L. Wolfe. (1987). “How Does Mother’s Schooling Affect Family Health, Nutrition, Medical Care Usage, and Household Sanitation?” *J. Econometrics* 36 (September–October): 185–204

[29] Besley, T., & Coate, S. (2003). “Centralized versus decentralized provision of local public goods: a political economy approach.” *Journal of public economics*, 87(12), 2611-2637.

[30] Bhagavan, M.R., and S. Giriappa. (1995). "Biomass, energy and economic and natural resource differentiation in rural Southern India." *Biomass and Bioenergy* 8 (3):181-190

[31] Bhargava : Bhargava, H. K. and V. Choudhary (2008) “Research Note: When is versioning optimal for information goods?”, *Management Science*, 54 (5), 1029-1035

[32] Bierstekker, T. J. (1990), "Reducing the role of the state in the economy: a conceptual exploration of IMF and World Bank prescriptions". *International Studies Quarterly*, 477-492

[33] Bodero, M. E. (2003), "Los servicios de saneamiento en el Perú: panorama del sector. Servicio Universitario Mundial del Canadá." *Agencia Canadiense para el Desarrollo Internacional.*

[34] Bonjour S, Adair-Rohani H,Wolf J, Bruce N, Mehta S, Prüss-Ustün A, et al. (2013) "Solid fuel use for household cooking: country and regional estimates for 1980–2010". *Environ Health Perspect*; 121:784–90.

[35] Boussofiane, Aziz, Stephen Martin, and David Parker. (1997) "The impact on technical efficiency of the UK privatization programme." *Applied Economics* 29.3: 297-310.

[36] Brouwer, R., and M.P. Falcão. (2004). "Wood fuel consumption in Maputo, Mozambique." *Biomass and Bioenergy* 27 (3):233-245.

[37] Bruce, N.G., R. Perez-Padilla, and R. Albalak. (2000). "Indoor air pollution in developing countries: a major environmental and public health challenge." *Bulletin of the World Health Organization* 78:1078-1092.

[38] Brune, N., G. Garrett and B. Kogut (2004), "The International Monetary Fund and the global spread of privatization," *IMF Staff Papers* 51 (2), 195-219

[39] Calderón J. (2004), Agua y Saneamiento: El Caso del Perú Rural. mimeo.

[40] Calzada, J. (2009), "Universal Service Obligations in the Postal Sector: The Relationship between quality and coverage", *Information Economics and Policy*, 21, 10-20.

[41] Calzada, J. and S. Iranzo (2014), "Neither private nor public: The effects of water communal provision on child health in Perú." *Working Paper.*

[42] Campbell, B.M., S.J. Vermeulen, J.J. Mangono, and R. Mabugu. (2003). "The energy transition in action: urban domestic fuel choices in a changing Zimbabwe." *Energy Policy* 31 (6):553-562.

[43] CARE-PROPILAS II (2005), “Experiencias de planificación estratégica en agua potable y saneamiento rural en municipalidades distritales.” *WSP*

[44] Carr, D., L. Suter, and A. Barbieri. (2005). "Population Dynamics and Tropical Deforestation: State of the Debate and Conceptual Challenges." *Population and Environment* 27 (1):89-113

[45] Carrasco Mantilla, William (2011), “Políticas Públicas para la prestación de los servicios de agua potable y saneamiento en las áreas rurales.” *CEPAL*. Naciones Unidas.

[46] Casarin, A.A., Delfino, J.A., Delfino, M.E., (2007). “Failures in water reform: lessons from the Buenos Aires's concession.” *Utilities Policy* 15, 234e247.

[47] Casey, K., R. Glennerster and E. Miguel (2012), “Reshaping Institutions: Evidence on Aid Impacts Using Preanalysis Plan,” *The Quarterly Journal of Economics*, 1755-1812

[48] Castillo, O. and Vera, R. (1998), “Descentralización, gobierno local y saneamiento básico rural.” Estudio de caso en el Perú. PAS BM, PNUD, Lima

[49] del Castillo, Laureano (2001). "El largo camino hacia una ley de aguas." Conferencia Electrónica "Legislación de Aguas: Propuestas desde el Desarrollo Rural"(12 de septiembre al l3 de octubre de 2001).

[50] CEPIS (1999). “Estudio de la calidad del agua en sistemas de abastecimiento rural: departamentos de Ancash, Apurímac, Cajamarca y Cusco”

[51] Chaurey, A., Malini, R. and Parimita, M. (2004). “Electricity access for geographically disadvantaged rural communities – technology and policy insights” *Energy Policy* Vol. 32 1693-1705

[52] Chone, P., L. Flochel and A. Perrot (2000), “Universal Service Obligations and Competition.” *Information Economics and Policy*, 12, 249-259.

[53] Chong, A. and F. López de Silanes (2004), “Privatization in Latin America: what does the evidence say?” *Economía* 4 (2), 37-111

[54] Chong, A. and Lopez-de- Silanes, F. eds. (2005) "Privatization in Latin America—Myths and Reality." Palo Alto, CA: *Stanford University Press.*

[55] Clark, A., Davis, M., Eberhard, A., Gratwick, K., Wamukonya, N., 2005. "Power Sector Reform in Africa: Assessing the Impact on Poor People." Graduate School of Business, University of Cape Town, Cape Town, pp. 1e144.

[56] Clarke, G.R.G., Wallsten, J.S., 2002. "Universal(ly Bad) Service: Providing Infrastructure Services to Rural and Poor Urban Consumers." *World Bank*, Washington, D. C (World Bank Policy Research Working Paper 2868).

[57] Clarke, George RG, Katrina Kosec, and Scott Wallsten. "Has private participation in water and sewerage improved coverage? Empirical evidence from Latin America." *Journal of International Development* 21.3 (2009): 327-361.

[58] Comisión Técnica Multisectorial (2009), "Política y estrategia nacional de recursos hídricos del Perú." *Autoridad Nacional del Agua*

[59] Conza, M., Flores, S. (2013), "Manual de Organización y Gestión de las Juntas Administradoras de Servicios de Saneamiento (JASS)." *Agua Limpia*

[60] Cooke, P., G. Köhlin, and W.F. Hyde. 2008. "Fuelwood, forests and community management – evidence from household studies." *Environment and Development Economics* 13 (01):103-135.

[61] Cornejo, R. (2012), "La agenda del Ministerio de Vivienda, Construcción y Saneamiento." Presentación en powerpoint done in 12 of april of 2012 in ESAN forum. Not published.

[62] Crampes, C. and A. Estache (1996), "Regulating Water Concessions: Lessons from the Buenos Aires Concession", Private Sector, Note no. 91, September, Washington, DC: *World Bank.*

[63] Cuervo, Alvaro, and Belen Villalonga. (2000) "Explaining the variance in the performance effects of privatization." *Academy of management review* 25.3: 581-590.

[64] Davis, M. (1998). "Rural household energy consumption: The effects of access to electricity—evidence from South Africa." *Energy Policy* 26 (3):207-217.

[65] Declaration, UN Millennium. Resolution adopted by the General Assembly. 55th Session, 2000, 8.

[66] Decreto Legislativo N^o 574

[67] Decreto Legislativo N^o 601. Procedimiento para la transferencia a que se refiere la Sétima Disposición Complementaria Transitoria del Decreto Legislativo N^o 574

[68] Decreto Supremo N^o 021-2012-EM

[69] Decreto Supremo 24-94-PRES Reglamento de la Ley General de la Superintendencia Nacional de Servicios de Saneamiento.

[70] Defensoría del Pueblo (2006), Informe defensorial N^o 39 - B. 2Diagnóstico sobre la calidad del agua para consumo humano en Colombia, en el marco del derecho humano al agua." Bogotá.

[71] Devkar, Ganesh A., et al. (2013) "Impact of Private Sector Participation on access and quality in provision of electricity, telecom and water services in developing countries: A systematic review." *Utilities Policy* 27: 65-81.

[72] Devoto, F., E. Duflo, P. Dupas, W. Parient and V. Pons (2012) "Happiness on tap. Piped water adoption in urban Morocco", *American Economic Journal: Economic Policy*, 4(4): 68–99 .

[73] Dey NC, Ali ARMM, Karim F (2012). "Knowledge and perceived health effects from exposure to indoor air pollution: findings from a population based cross-sectional study in rural Bangladesh." (unpublished report).

[74] DHS (2011), Encuesta demográfica y de salud familiar. Instituto Nacional de Estadística e Informática (INEI), Lima, Peru and OCF International.

[75] Elias, Rebecca J., Victor, David G., (2005). "Energy transition in developing countries: a review of concepts and literature". In: Program on

Energy and Sustainable Development, *Working Paper*. Stanford University: Stanford.

[76] ENAHO (2011). Encuesta Nacional de Hogares.

[77] ESMAP (2002), "Household Energy, Indoor Air Pollution, and Health". Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP), Washington, DC.

[78] ESMAP (2003a), "India: Access of the Poor to Clean Household Fuels". Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP), Washington, DC.

[79] ESMAP (2003b), "Household Energy Use in Developing Countries: A Multicountry Study". Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP), Washington, DC.

[80] ESMAP (2004), "Indoor Air Pollution Associated with Household Fuel Use in India: An Exposure Assessment and Modeling Exercise in Rural Districts of Andhra Pradesh, India". Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP), Washington, DC.

[81] Espinoza, W. (1997), "Los Incas: Economia, Sociedad y Estado en la Era de Tahuantinsuyo", AMARU Editores, Lima.

[82] Esrey, S. A., Potash, J. B., Roberts, L., & Shiff, C. (1991). "Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma". *Bulletin of the World Health organization*, 69(5), 609.

[83] Estache, Antonio, Vivien Foster, and Quentin Wodon. (2002). "Accounting for Poverty in Infrastructure Reform: Learning from Latin America's Experience". Washington: World Bank, *World Bank Institute Development Studies*

[84] Estache, A. and M.A. Rossi (2002), "How Different Is the Efficiency of Public and Private Water Companies in Asia?", *World Bank Economic* Review Volume 16 (1), 139 - 147.

[85] Estache, A. and E. Kouassi (2002), "Sector Organization, Governance, and the Inefficiency of African Water Utilities", *World Bank Research Working Paper* 2890, Washington, DC: World Bank.

[86] Estache, A. (2004). "Emerging infrastructure policy issues in developing countries: a survey of the recent economic literatura" (Vol. 3442). *World Bank Publications.*

[87] Estache, A and Wren-Lewis, L. (2009). "Towards a Theory of Regulation for Developing Countries: Following Jean-Jacques Laffont's Lead" *Journal of Economic Literature,* September 47(3):729-70

[88] Estache, A and Wren-Lewis, L. (2010). "Regulation in Developing Economics: A survey of theory and evidence" in Baldwin, R., M. Cave and M. Lodge (ed) *Oxford Handbook of Regulation.*

[89] Estache, A. And Philippe, C. (2012), "The Impact of Private Participarion in Infrastructure in Developing Countries: Taking Stock of about 20 Years of Experience,“ *Working Papers ECARES.*

[90] Estache, A. and Grifell-Tatjé, E. (2013). "How (un)even was the distribution of the impacts of Mali's water privatization across stakeholders?" *Journal of Development Studies*, Volume 49 (4), April, pages 483-499

[91] Ezzati M and D Kammen (2001). "Indoor air pollution from biomass combustion as a risk factor for acute respiratory infections in Kenya: an exposure-response study". *Lancet* 358(9282):619- 24.

[92] FANCA (2006), "Las Juntas de Agua en Centroamérica. Valoración de la gestión local del recurso hídrico", *Red Centroamericana de Acción del Agua.*

[93] Fink, C., Mattoo, A. and R. Rathindran, (2002), "An Assessment of Telecommunications Reform in Developing Countries", *World Bank Policy Research Working Paper* 2909, Washington, DC: World Bank.

[94] Foster, Vivien, Tre, Jean-Philippe, Wodon, Quentin, (2000). "Energy Consumption and Income: an Inverted-U at the Household Level?". *World Bank*, Washington.

[95] GACC (Global Alliance for Clean Cookstoves). (2014a). “Post-Summit Report.” Washington, D.C.: GACC. Available at http://www. http://cleancookstoves.org/resources/284.html

[96] GACC (Global Alliance for Clean Cookstoves). (2014b). “Guatemala Country Action Plan For Clean Cookstoves and Fuels.” Available at http://cleancookstoves.org/resources_files/guatemala-cap-annexes.pdf

[97] Galiani, S., P. Gertler and E. Schargrodsky. (2005). “Water for life: The impact of the privatization of water services on child mortality.” *Journal of political economy*, 113(1), 83-120.

[98] Galiani, S., P. Gertler, E.Schargrodsky, and F. Sturzenegger. (2005). “The Benefits and Costs of Privatization in Argentina: A Microeconomic Analysis.”

[99] Galiani, S., M. González-Rozada. and E. Schargrodsky. (2009). “Water expansions in shantytowns: Health and savings.” *Economica*, 76(304), 607-622.

[100] García-Frapolli, E., A. Schilmann, V.M. Berrueta, H. Riojas-Rodríguez, R.D. Edwards, M. Johnson, A. Guevara-Sanginés, C. Armendariz, and O. Masera. 2010. "Beyond fuelwood savings: Valuing the economic benefits of introducing improved biomass cookstoves in the Purépecha region of Mexico." *Ecological Economics* 69 (12):2598-2605.

[101] Garrido-Lecca, H. (2010), “Inversión en agua y saneamiento como respuesta a la exclusión en el Perú: gestación, puesta en marcha y lecciones del Porgrama Agua para Todos (PAPT)”. *Cepal.* Naciones Unidas.

[102] Gassner, K., A. A. Popov and N. Pushak (2009). “Does private sector participation improve performance in electricity and water distribution?” (No. 6). *World Bank* free PDF.

[103] Gestores Comunitarios de Desarrollo. *Revista Aquae Vitae.* Año 6. (2010). N^o 12: 10-20.

[104] Glennerster, R., E. Miguel and A. Rothenberg (2013), “Collective Action in Diverse Sierra Leone Communities”, *The Economic Journal*, 123 (May), 285-316.

[105] Global Burden of Disease. Data 2010. Available at http://vizhub.healthdata.org/gbd-compare/

[106] "Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013". *The Lancet.* 2014 Dec 17. doi: 10.1016/S0140-6736(14)61682-2.

[107] GNESD, (2006), "Regional Workshops on Electricity and Development in Africa, Asia and Latin America", *Global Network on Energy for Sustainable Development*, Denmark.

[108] Gomez-Ibanez, J.A. (2005), "EDM (Energie du Mali)," Case 1811.0 Kennedy School of Government, Harvard University

[109] Granderson, J., Sandhu, J.S., Vasquez, D., Ramirez E. and Smith, K.R. (2009), "Fuel Use and Design Analysis of Improved Woodburning Cookstoves in the Guatemalan Highlands", Berkeley.

[110] Gutierrez, L.H. and S. Berg, (2000), "Telecommunications Liberalization and Regulatory Governance: Lessons from Latin America", *Telecommunications Policy*, Vol.24, pp.865–84.

[111] Hailu, D., Guerreiro Osorio, R., & Tsukada, R. (2012), "Privatization and renationalization: what went wrong in Bolivia's water sector?" *World Development*, 40(12), 2564–2577.

[112] Hanna, R., Duflo, E., & Greenstone, M. (2012). "Up in smoke: the influence of household behavior on the long-run impact of improved cooking stoves" (No. w18033). *National Bureau of Economic Research.*

[113] Heltberg, R. (2004). "Fuel switching: evidence from eight developing countries." *Energy Economics* 26 (5):869-887.

[114] Heltberg, R. (2005). "Factors determining household fuel choice in Guatemala." *Environment and Development Economics* 10 (03):337-361.

[115] Hiemstra-van der Horst, G., and A. J. Hovorka. (2008). "Reassessing the "energy ladder": Household energy use in Maun, Botswana." *Energy Policy* 36 (9):3333-3344.

[116] Hosier, R. H., and J. Dowd. (1987). "Household fuel choice in Zimbabwe: An empirical test of the energy ladder hypothesis." *Resources and Energy* 9 (4):347-361.

[117] Hosier, R.H. and Kipondya, W. (1993). "Urban household energy use in Tanzania: prices, substitutes and poverty. *Energy Policy* 21 453-573

[118] IEA (International Energy Agency). (2013a). "World Energy Outlook 2013. Chapter 2 Extract: Modern Energy for All". Paris: IEA.

[119] IEA (International Energy Agency). (2006). "World Energy Outlook 2006". Paris: IEA.

[120] INEI (2010), "Perú: Mapa del Déficit de Agua y Saneamiento Básico a Nivel Distrital, 2007". Instituto Nacional de Estadística e Informática.

[121] Informe Anual 2013 FISE.

[122] Informe Anual 2014 FISE.

[123] Jain, G. (2010). "Energy security issues at household level in India." *Energy Policy* 38 (6):2835-2845.

[124] Jalan, Jyotsna, and Martin Ravallion. (2003). "Does Piped Water Reduce Diarrhea for Children in Rural India?" *J. Econometrics* 112 (January): 153–73.

[125] Katz, T. and J. Sara (1997), "Making rural water supply sustainable: recommendations from a global study". *Water and Sanitation Program*, Washington, D.C.

[126] Keener, S., M. Luengo and S. Banerjee (2010) "Provision of water to the Poor of Africa. Experience with water standpoints and the informal water sector", *The World Bank*, Policy Research Working Paper, 5387.

[127] Kirkpatrick, C., D.Parker and Y-F. Zhang (2006), "Stata versus private sectro provision of water services in Africa: An empirical analysis", *The World Bank Economic Review.* Vol 20 (1), 143-163

[128] Kojima, M., R. Bacon, and X. Zhou. (2011). "Who Uses Bottled Gas? Evidence from Households in Developing Countries", WPS5731. Washington, D.C.: *The World Bank.*

[129] Kosek, M., C. Bern, and R. L. Guerant. (2003). "The Global Burden of Diarrheal Disease, As Estimated from Studies Published between 1992 and 2000." B*ulletin of the World Health Organization* 81(3):197–204.

[130] Kosec, K. (2014). "The child health implications of privatizing Africa's urban water supply". *Journal of health economics*, 35, 1-19.

[131] Laffont, J. J. and A. N'Gbo (2000), "Cross-subsidies and network expansionin developing countries", *European Economic Review*, 44 (4), 797-805

[132] Laffont, J. J. Estache, A. Zhang, X. (2004), "Universal service obligations in developing countries", *World Bank*

[133] Lavy, Victor, John Strauss, Duncan Thomas, and Philippe de Vreyer. (1996). "Quality of Health Care, Survival and Health Outcomes in Ghana." *J. Health Econ.* 15 (June): 333–57.

[134] Leach, G. (1992). "The energy transition." *Energy Policy* 20 (2):116-123.

[135] Lee, Lung-fei, Mark R. Rosenzweig, and Mark M. Pitt. (1997). "The Effects of Improved Nutrition, Sanitation, and Water Quality on Child Health in HighMortality Populations." *J. Econometrics* 77 (March): 209–35.

[136] Lee, C., (2001). "Telecommunications Reforms in Malaysia". University of Malaysia, Malaysia.

[137] Lee, M. M., Walter-Drop, G., & Wiesel, J. (2014). "Taking the State (Back) Out? Statehood and the Delivery of Collective Goods". *Governance*, 27(4), 635-654.

[138] Ley N^o 26338. Ley General de Servicios de Saneamiento. 24 de julio de 1994

[139] Ley N^o 27972. Ley Orgánica de Municipalidades. 27 de mayo de 2003

[140] Ley N^o 29852. Ley que crea el sistema de seguridad energética en hidrocarburos y el fondo de inclusión social energético. Ministerio de Energía y Minas. 13 de abril de 2012

[141] Ley N^o 29969

[142] Ley N^o 30114

[143] Lim, S. S., T. Vos, A. D. Flaxman, G. Danaei et al. (2012). "A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010." *The Lancet* 380 (9859):2224-2260.

[144] Liu, J., G. Daily, P. Erlich, and G. Luck. (2003). "Effects of household dynamics on resource consumption and biodiversity." *Nature* 421:530-533.

[145] López Moreno, B. (2012), "Servicios de Agua Potable en el Ámbito Rural". Informe Temático N^o 06/2012-2013.

[146] Malla, M. B., N. Bruce, E. Bates, and E. Rehfuess. (2011). "Applying global cost-benefit analysis methods to indoor air pollution mitigation interventions in Nepal, Kenya and Sudan: Insights and challenges." *Energy Policy* 39 (12):7518-7529.

[147] Mansuri, G., & Rao, V. (2004). "Community-based and-driven development: A critical review". *The World Bank Research Observer*, 19(1), 1-39.

[148] Mara, D. and G. Alabaster (2008) "A new paradigm for low-cost urban water supplies and sanitation in developing countries". *Water Policy*, 10, p. 119-129.

[149] Marañón, B., (2005). "Private-sector participation in the management of potable water in Mexico City", 1992e2002. *International Journal of Water Resources Development* 21, 165-179

[150] Marks, S. J., Komives, K., & Davis, J. (2014). "Community Participation and Water Supply Sustainability Evidence from Handpump Projects in Rural Ghana". *Journal of Planning Education and Research*, 0739456X14527620.

[151] Masera, O. R., B. D. Saatkamp, and D. M. Kammen. (2000). "From Linear Fuel Switching to Multiple Cooking Strategies: A Critique and Alternative to the Energy Ladder Model." *World Development* 28 (12):2083-2103.

[152] Matos, M.G., V. Coquies and R. Nuñez (2008), "Gestión comunitaria de los servicios públicos. Las Mesas Técnicas de Agua como herramienta para el desarrollo comunitario", en M. Córdova Lo urbano en si complejidad: una lectura desde América Latina, FLASCO y Ministerio de Cultura de Ecuador.

[153] Megginson, William, and Jeffry Netter. (2001). "From State to Market: A Survey of Empirical Studies on Privatization." *Journal of Economic Literature* 39(2): 321–89.

[154] Memoria Anual de Gestión FISE 2012-2013

[155] Memoria Anual de Gestión FISE 2013-2014

[156] Merrick, Thomas W. (1985). "The Effect of Piped Water on Early Childhood Mortality in Urban Brazil, 1970 to 1976." *Demography* 22 (February): 1–24.

[157] McKenzie, D., D. Mookherjee, G. Castañeda and J. Saavedra (2003). "The Distributive Impact of Privatization in Latin America: Evidence from Four Countries [with Comments]". *Economia*, 3(2), 161-233.

[158] Miguel, E., & Gugerty, M. K. (2005). "Ethnic diversity, social sanctions, and public goods in Kenya". *Journal of public Economics*, 89(11), 2325-2368.

[159] Mirabel, F., J.-C. Poudou and M. Roland (2009) "Universal Service Obligations: The role of subsidization schemes", *Information Economics and Policy*, 21, 1-9.

[160] Miranda, M., Aramburú, A., Junco, J., & Campos, M. (2010). "Situación de la calidad de agua para consumo en hogares de niños menores de cinco años en Perú, 2007-2010". *Revista Peruana de Medicina Experimental y Salud Pública*, 27(4), 506-511.

[161] Mobarak, A. M., P. Dwivedi, R. Bailis, L. Hildemann, and G. Miller. (2012). "Low demand for nontraditional cookstove technologies." Proceedings of the National Academy of Sciences 109 (27):10815-10820.

[162] Moorthy, K. S. (1984), "Market segmentation, self-selection, and product line design", *Marketing Science*, 3 (4), 288-307

[163] Mussa, M. and S. Rosen (1978), "Monopoly and product quality", *Journal of Economic Theory* 18, 301-317

[164] MVCS (2003), "Estudios de base para la implementación de proyectos de agua y saneamiento en el área rural". Programa Nacional de Agua y Saneamiento Rural. Ministerio de Vivienda, Construcción y Saneamiento / COSUDE / PAS - BM.

[165] MVCS and WSP (2007), "Evaluación de los operadores locales de pequeña escala de agua y saneamiento en el Perú". Ministerio de la Vivienda, Construcción y Saneamiento .

[166] MVCS (2011), "Construcción y Saneamiento. Manual de Operaciones: Programa Nacional de Agua y Saneamiento Rural PRONASAR 2011-2013"

[167] Narasimha, R.M., and B.S. Reddy. (2007). "Variations in energy use by Indian households: An analysis of micro level data." *Energy* 32 (2):143-153.

[168] Nlom, J.H., and A.A. Karimov. (2014). "Modeling Fuel Choice among Households in Northern Cameroon". Working Paper 2014/038. Helsinki: World Institute for Development Economics Research (WIDER).

[169] Nnaji, C. E., E.R. Ukwueze, and J.O. Chukwu. (2012). "Determinants of household energy choices for cooking in rural areas: evidence from Enugu State, Nigeria." *Continental Journal of Social Sciences* 5 (2):1-11.

[170] Oblitas de Ruiz, L. (2011), "Servicios de agua potable y saneamiento en el Perú: beneficios potenciales y determinanyes del éxito". *CEPAL.* Naciones Unidas.

[171] OPS (2005), "Guía para Juntas Administradoras de Agua y Saneamiento (JASS) y entidades afines". Organización Panamericana de la Salud.

[172] Ouedraogo, B. (2006). "Household energy preferences for cooking in urban Ouagadougou, Burkina Faso." *Energy Policy* 34 (18):3787-3795

[173] Pachauri, Shonali, Daniel, Spreng, (2003). "Energy use and energy accessin relation to poverty", in *CEPE Working Paper.* CEPE, ETH Zentrum: Zurich, June 2003.

[174] Pandey, V. L., and A. Chaubal. (2011). "Comprehending household cooking energy choice in rural India." *Biomass and Bioenergy* 35 (11):4724-4731.

[175] Parikh J. (2011) “Hardships and health impacts on women due to traditional cooking fuels: a case study of Himachal Pradesh, India.” *Energy Policy*;39(12):7587–94

[176] Peer Review on Fossil Fuel Subsidy Reforms in Peru, April (2015), *APEC*

[177] Plan de Acceso Universal a la Energía 2013-2022, *Ministerio de Energía y Minas*

[178] Pou, B. and M. Campos (2001), “Participación comunitaria en salud: los proyectos de agua y saneamiento”. *CARE PERU*, Serie Lecciones 1, Lima.

[179] Prizzia, Ross. (2001) "Privatization and social responsibility: a critical evaluation of economic performance." *International Journal of Public Sector Management* 14.6: 450-464.

[180] Prokopy, L., R. Thorsten, A. Bakalian and W. Wakeman (2008), “Evaluating the Role of Postcontruction Support in Sustaining Drinking Water Projects”. Evidence from Peru. *Journal of Planning Education and Research.* 294.

[181] PROPILAS (2009), “Proyecto Piloto para Fortalecer la Gestión Regional y Local en Agua y Saneamiento en el Marco de la Descentralización en Cajamarca”.

[182] PROTOS-CEDIR (2011), “Yakukamay. Alianza público-comunitarias: un modelo de gestión desde el CENAGRAP”. Municipio de Cañar. Juntas Administradoras de Agua Potable de Cañar.

[183] Ramamurti, R. (1992), “The impact of privatizationon the Latin American debt problema”, *Journal of Interamerican Studies and world affairs* 34 (2), 93-125

[184] Reconocimiento del Uso del Recurso Hídrico por los Diferentes Sectores Productivos en el Perú. Capítulo VI.

[185] Resolución Ministerial 205-2010 Vivienda. Lima, 27 de diciembre de 2010.

[186] Resolución Ministerial 207-2010 Vivienda. Lima, 27 de diciembre de 2010.

[187] Rojas, G., McGregor, J. and Beltrán, I. (1999), "La sostenibilidad de los servicios de saneamiento rural". *AGUA Boletín del Comité Sectorial de Agua y Saneamiento*, N^o 3, Lima, mayo.

[188] Ros, A.J. and A. Banerjee, (2000), 'Telecommunications Privatization and Tariff Rebalancing: Evidence from Latin America', *Telecommunications Policy*, Vol.24, pp.233–52

[189] Ruiz-Mercado I, Masera O, Zamora H, Smith KR. (2011) "Adoption and sustained use of improved cookstoves." *Energy Policy*;39(12):7557–66.

[190] Salant, S. W. (1989), "When is inducing self-selection suboptimal for a monopolist?", *The Quarterly Journal of Economics*, 104 (2), 391-397

[191] Salinas Rivas, S. (2013), "Del tango a la cumbia: reflexiones sobre la experiencia del rescate de la concesión de agua en Tumbes". *Revista justicia y derecho*. Número 8. Año 2013.

[192] Señales de Competitividad de las Américas (2014), *Red Interamericana de Competitividad* (RIAC), OEA

[193] Shirley, Mary M., and Patrick Walsh. (2001) "Public vs. private ownership: the current state of the debate." *World Bank Policy Research Working Paper* 2420.

[194] Singh, A., Tuladhar, B., Bajracharya, K., & Pillarisetti, A. (2012). "Assessment of effectiveness of improved cook stoves in reducing indoor air pollution and improving health in Nepal". *Energy for Sustainable Development*, 16(4), 406-414.

[195] Smits, S., S.P.Tamayo, V. Ibarra, J. Rojas, A. Benavidez, and V. Bey (2012), "Gobernanza y sostenibilidad de los sistemas de agua potable y saneamiento rurales en Colombia". (Monografia No. IDB-MG-133) Washington, D.C.: Banco Interamericano de Desarrollo.

[196] Sorana, V. (2000), "Auctions for universal service subsidies", *Journal of Regulatory Economics*, 18 (1), 33-58

[197] Soto, F. (1999), "Estudio de sostenibilidad de los servicios de agua en el área rural del Perú". Informe preliminar. Lima. PAS Banco Mundial.

[198] Spaling, H., Brouwer, G., & Njoka, J. (2014). "Factors affecting the sustainability of a community water supply project in Kenya". *Development in Practice*, 24(7), 797-811.

[199] Stokey, N. L. (1979) "Intertemporal Price Discrimination", *Quarterly Journal of Economics* 93 (3), 355-371

[200] Tamayo, G., R. Barrantes, E. Conterno and A. Bustamante (2000) "Esfuerzos de reforma y equilibrio de bajo nivel del sector del agua de Peru", in P.T. Spiller and W.D. Savedoff (ed.) *Agua Perdida*, Inter-American Development Bank, Washington.

[201] Tan, J. (2012), "The Pitfalls of Water Privatization: Failure and Reform in Malaysia", *World Development*, Volume 40 (12), 2552–2563.

[202] The World Bank (1995) The World Bank, "World Development Report" (1995) Washington, D.C.

[203] Tremolet, S., Neale, J., (2002). "Emerging Lessons in Private Provision of Infrastructure Services in Rural Areas: Water and Electricity Services in Gabon". T*he World Bank/PPIAF*, Washington, D. C.

[204] Valletti, T., S. Hoernig and P. Barros (2002) "Universal service and entry: the role of uniform pricing and coverage constraints", *Journal of Regulatory Economics*, 18, 235-245.

[205] Valletti, T., and S. Szymanski (2006), "Parallel trade, international exhaustion and intellectual properties rights: a welfare analysis", *The Journal of Industrial Economics*, 54 (4), 499-526

[206] Van de Walle (1989) "Privatization in developing countries: a revie of the issues", *World Development*, 17, 601-615

[207] Venkataraman, C, A. D. Sagar, G. Habib, N. Lam, and K.R. Smith. (2010). "The Indian national initiative for advanced biomass cookstoves:

the benefits of clean combustion." *Energy for Sustainable Development* 14 (2):63-72.

[208] Wallsten, S., and K. Kosec. (2008). "The effects of ownership and benchmark competition: An empirical analysis of US water systems." *International Journal of Industrial Organization*, 26(1), 186-205.

[209] Wang, Limin. (2003) "Determinants of child mortality in LDCs: empirical findings from demographic and health surveys." *Health policy* 65.3: 277-299.

[210] Whittington, D., Davis, J., & McClelland, E. (1998). "Implementing a demand-driven approach to community water supply planning: A case study of Lugazi, Uganda." *Water international*, 23(3), 134-145.

[211] Whittington, D., J. Davis, L. Prokopym K. Komives, R. Thorsten, H. Lukacs, A. Balalian, and W. Wakeman (2009), "How well is the demand-driven, community management model for rural supply systems doing? Evidence from Bolivia, Peru and Ghana", *Water Policy*, 11, 696-718.

[212] WHO (World Health Organization). (2000). "Global Water Supply and Sanitation Assessment". Geneva: WHO. ————. 2002. *World health report* 2002. Geneva: WHO.

[213] WHO (2005). "World Health Statistics 2005". WHO

[214] WHO. (2006a). "Fuel for Life: Household Energy and Health". Geneva: WHO.

[215] WHO. (2006b). "Evaluation of the costs and benefits of household energy and health interventions at global and regional levels". Geneva: WHO.

[216] WSP (2003), "Los servicios de agua y saneamiento en el Perú: un diagnóstico y estadísticas". *Water and Sanitation Program.*

[217] WSP (2007), "Memoria del taller PRONASAR-PPPL. Servicios sostenibles con nuevos modelos de gestión para las pequeñas ciudades del Perú". *Water and Sanitation Program.*

[218] WSP (2007a), "Los nuevos operadores en las pequeñas ciudades del Perú: Diseño de un nuevo modelo de gestión sostenible de los servicios de agua y saneamiento." *Water and Sanitation Program.*

[219] WSP (2007n), "Un nuevo acuerdo social. El cambio de modelo de gestión para mejorar la sostenibilidad de los servicios de agua y saneamiento en las pequeñas ciudades." *Water and Sanitation Program.*

[220] WSP (2008), "Operadores locales de pequeña escala en América Latina. Su participación en la prestación de los servicios de agua y saneamiento". *Water and Sanitation Program.*

[221] Wu, X. and N. A. Malaluan (2008) "A tale of two concessionaries: A natural experiment of water privatisation in Metro Manila", *Urban Studies*, 45 (1), 207-229.

[222] Zhang J, Smith KR, et al. (2000) "Greenhouse gases and other airborne pollutants from household stoves in China: a database for emission factors." *Atmos Environ* 34(26):4537–49.

[223] Zhang, Y.-F., Parker, D. and C. Kirkpatrick, (2002), "Electricity Sector Reform in Developing Countries: An Econometric Assessment of the Effects of Privatisation, Competition and Regulation", Working Paper No.31, Centre on Regulation and Competition, Institute for Development Policy and Management, University of Manchester.

[224] Zhang, Y.-F., Parker, D. and C. Kirkpatrick, (2003), "Competition, Regulation and Privatisation of Electricity Generation in Developing Countries: Does the Sequencing of the Reforms Matter?", mimeo, Centre on Regulation and Competition, Institute for Development Policy and Management, University of Manchester.