Impact of Increased Access and Price on Household Water Use in Urban Bolivia

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Abstract

Using the 1994 Bolivian Integrated Household Survey, this study analyzes the equity implications of urban water sector reform including both increased water prices and increased access to piped water. Household water expenditures are examined by income decile and low-income households are found to spend a higher percentage of income on water than high-income households. However, households purchasing from private water vendors could benefit from obtaining piped water, since regression analysis shows that, on average, these households spend more on water than those with piped water inside their buildings or yards. This differential was the greatest in the city of Cochabamba, which also had the largest percentage of households purchasing from private water vendors. To understand the equity impact of water reform, the effects on both pre-reform users of piped water and those without access to piped water must be considered.

Biographical sketch:

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Introduction

The problems faced in providing urban household water in Bolivia are common in many developing countries. Often urban water systems do not extend to all households and may not adequately serve households that are connected. Rapid urban growth exacerbates these problems. Two common characteristics of these water systems are lack of funds to expand water system coverage while water is priced below the marginal costs of provision, effectively subsidizing households with access to piped water. This has been described as the "low-level equilibrium trap" (Walker et al., 1999).[1] Since water is a basic necessity, governments may be reluctant to allow price increases to cover the costs of water provision. Although the hardship on poor households of high water prices is often given as a reason to keep water prices low, poor households may actually be disproportionately affected by reduced access to piped water. Due to this "low-level equilibrium trap," the benefits of water reform are dependent on the extent of initial coverage, as existing customers will lose from the price increase while new customers will gain from expanded coverage (Clarke et al., 2002; Walker et al., 2000).[2] The gain to new customers may involve both increased water consumption and lower prices, as found by Walker et al. (1999) in Honduras.

This paper examines the equity implications of urban water reform, using data on household water expenditures and water sources from the 1994 Bolivian Integrated Household Survey.[3] Specifically, this paper examines the distribution of both the impact of price increases on households with access to piped water pre-reform and the potential impact of expanded coverage on households without access to piped water pre-reform.

The importance of household access to clean water sources has long been recognized as a development goal, as in the International Drinking-Water, Supply and Sanitation Decade declared by the United Nations in the 1980s and more recently in the United Nations' Millennium Development Goals (Esrey et al., 1991; Komives, 2005). Improved access to water has important health implications (Esrey, 1996; Esrey et al., 1991; Hutton and Haller, 2004). Quantity of water used, as well as the quality of water available, has been shown to reduce the prevalence of certain diseases and of child mortality (Esrey et al., 1991). While this paper focuses on access to water and spending on water, water quality is also a concern in Bolivia, including for piped water provided by water companies (Nickson and Vargas, 2002).

Examining who benefits and who is hurt by water reform using empirical evidence is particularly important due to the tendency to politicize these issues. In recent years political turbulence has kept Bolivia in the news and been a source of uncertainty and instability for the country. Along with natural gas, water has been a focal point for anti-government protests, first in Cochabamba in 2000 and more recently in El Alto in 2005 (Spronk and Webber, 2005). In Cochabamba, protests about privatization of water distribution and the accompanying increases in water tariffs, succeeded first in blocking the tariff increase (intended to cover the costs of new water projects) and then in cancelling the contract for the private concession altogether (Schultz, 2000).[4] In La Paz and El Alto, the concession for urban water distribution was awarded to a private firm (Aguas del Illimani) in 1997 and according to an early evaluation, a successful expansion of water access to low-income households occurred (Komives, 1999). However, dissatisfaction with the private firm led to popular protests demanding cancellation of the contract. The government agreed to cancel the contract early in 2005 (Ballvé, 2005). The cooperative water company in the other large city in Bolivia, Santa Cruz, has successfully increased the percentage of households with access to piped water (World Bank Operations Evaluation Department, 2002).[5]

In both of the cases when the water distribution was granted to private concessions, the new tariff structure used was an increasing block rate (See Appendix Table A). To the extent that low income households also are low water users, this should lessen the burden of water price increases on those who can least afford them. However, as pointed out by Whittington (1992), the conventional wisdom that increasing block water tariffs will necessarily provide water at lower rates to low income customers may not hold true under all conditions in developing countries, particularly if lower income households are more likely to share water meters in crowded living conditions.

In La Paz/El Alto, changes in the water tariff structure were made when the private provider began operation, along with tariff increases. Before any price reforms had occurred, the public water utility had provided the first 10 cubic meters free of charge, while the average water price was about $US 0.32 per cubic meter (Barja and Urquiola, 2003). In Cochabamba considerable controversy exists over the impact of the water price increases when Aguas del Tunari began its water concession.[6] The water tariff structure was defined separately for four types of residential users (as before) and the new tariffs had an increasing block rate structure (see Appendix Table A). While the average price increase was 38 percent, because of recategorization of households, some households experienced much higher price increases (Barja and Urquiola, 2003). The issues surrounding privatization of water resources are clearly more complex than simply changes in pricing policies. This paper does not directly evaluate the benefits or drawbacks of public versus private provision of water services.[7]

According to other studies in urban areas of developing countries, households without piped water often pay higher prices for water than those with piped water and may spend a high percentage of their income on water (Cairncross and Kinnear, 1992; McPhail, 1994; Plummer, 1999; Whittington et al., 1991). Brookshire and Whittington (1993) review various studies and conclude that water purchased from private water vendors is generally more expensive than other options. However, Solo (1998) cautions that the private water vending situation is not uniform across countries, citing examples from Guatemala and Paraguay where prices for private vended water ranged from 1.4 to 2.4 times the price of piped water. Solo suggests that small-scale water providers may increase efficiency in the sector and respond to unmet demand. The examination of this issue for Bolivia is a key contribution of this paper. If households in urban Bolivia without access to piped water are paying more for water, then they would benefit from increased access to piped water.

Even if piped water is less expensive per unit than water purchased from private water vendors, households purchasing from private water vendors may still not connect to the piped water system when the water system expands, if the fixed cost of connection is too high. This is particularly likely if a household faces credit constraints and must pay the whole amount at once. Asthana (1997), Briscoe, et al. (1990), McPhail (1994), and North and Griffin (1993) examine household choice of water source or willingness to pay to connect to piped water. The probability of connecting to a piped water system is found to increase with income. Also, in one study, higher-income households are found to be more likely to choose a private than a communal water source. However, as a percentage of income willingness to pay for water connections or the percentage of income spent on water was decreasing with income. McPhail (1994) highlights initial connection costs as a deterrent to connecting to piped water for those who could connect at their location, but choose not to. However, a water reform can be designed to encourage new connections, by allowing payment over time or by finding ways to reduce the cost of the connection, such as allowing households to substitute their labor for a lower connection cost. This type of cost reduction has been attempted recently in El Alto, Bolivia, with the "condominial" water and sewerage system (Foster, 2001). However, increases in connection fees were a key part of the protests against Aguas del Illimani, the private water service provider in El Alto and La Paz, with reported connection fees for water and sewage combined of more than $445 (Ballvé, 2005).

The distribution of the impact of privatization in various sectors, including water, was examined for urban Bolivia by Barja and Urquiola (2003). Examining 1994 data, they find percentages of households with water connections increased with income, suggesting that an increase in available connections would disproportionately assist those in lower income categories.[8] While my study also examines how water connections vary with income, a new contribution is the examination of different types of connections and water sources in further detail. For the four cities of El Alto, La Paz, Cochabamba, and Santa Cruz, Barja and Urquiola (2003) also examine the change in average water spending by household income quintile, concluding that relative to income, price increases have a regressive impact on those already connected to piped water (placing a higher burden as a percentage of income on low income relative to high income households). This regressive impact is generally what one would expect from the results of Timmins (2002) in California and Walker et al. (2000) in various Latin American cities. Water demand is usually found to be inelastic with respect to income, also consistent with across the board water price increases having a regressive impact (Cairncross and Kinnear, 1992; Galindo, 1999; Rietveld et al., 2000). This paper examines the potential impact of water price increases by looking at water expenditures as a percentage of income by income decile for urban Bolivia.

Empirical Strategy

First, the distribution of the burden of increasing water prices on piped water users is examined by looking at household water expenditures by income decile. This is essentially an estimation of the static burden of an across the board price increase. Looking at Figure 1, which depicts a household's demand for water, the static burden of a price increase is $(P_1 - P_0)Q_0$ which encompasses areas a, b, c, d, and e. If demand for water is perfectly inelastic, then water use does not change when the price increases and the static burden estimate reflects the burden. However, if demand is not perfectly inelastic (as reflected with demand curve, D) when the price increases, water use decreases, and the static burden overestimates the burden by area c + d. On the other hand, if rationing exists pre-reform, reflected in Q_R, a restricted amount purchased at price P_0, the static burden overestimates the burden by a smaller amount (c only).

The distributional impact of a water price increase may be described as regressive, progressive, or proportional. Burdens may be examined either in absolute or relative terms. With absolute progressivity the burden is greater in monetary terms for high-income groups than for low-income groups, whereas with relative progressivity, the burden as a proportion of income is increasing with income. If price increases are the same for all income groups, then if low-income households spend a larger percentage of income on water than do high-income households, these across the board water price increases would be regressive. While the structure of water price increases often will not be a simple across the board increase, as seen in the previous section, targeting price increases to households of specific income categories may prove difficult, and increasing block tariffs do not always result in charging higher prices to higher income households.

If price elasticities of demand vary with household income, including partial equilibrium effects would result in a less regressive impact if low-income households had more elastic demand than high-income households and vice versa. In previous studies, Agthe and Billings (1987) and Rietveld et al. (2000) found that low-income households had slightly more elastic demand with respect to price than high-income households. In that case, the regressivity of water price increases would be less than that implied by pre-reform water expenditure patterns.

The impact of rationing could also differ with income. Higher income households may have a better ability to protect themselves from the rationing (such as installing large water storage tanks). However, households may adopt various manners of storing water, in addition to installing large water tanks, that will reduce the impact of water rationing for households at all income levels. These often include storing water in outdoor barrels, bathtubs, sinks and buckets. If lower income households are affected by rationing more than higher income households, then this reduces the amount by which the static burden overestimates the actual burden of the price increases (as illustrated in Figure 1). Therefore, with lower income households affected more by rationing, the static burden makes the price increases look less regressive (by showing smaller water expenditures for lower income households because of the rationing). On the other hand, a water reform that reduced rationing would provide a benefit to certain households that had been previously affected by rationing. If the pre-reform rationing had caused a household to purchase less at the lower prices than they end up purchasing post-reform at the higher prices (on Figure 1, less than Q_1) then the actual burden of the higher prices would be reduced by the reduction in deadweight loss from rationing.

Another impact of water reform which includes both higher prices and expanded water access, is that households without piped water may benefit from gaining piped water access. These households fall into two general categories: those obtaining water from “free” sources such as wells, streams, lakes, irrigation ditches or rivers and those purchasing their water from private water vendors. Therefore, second, the income distribution of households with piped water is compared to that for households without piped water access, to gain insight into the distributional impact of expanding piped water access.

A comparison of water costs between households with piped water and those without would allow estimation of the benefits of increased piped water access. This is not possible for households without explicit water expenditures. However, households purchasing from private water vendors report water expenditures. These households might reduce their water expenditures and benefit from increased access to piped water if private vended water is more expensive. Therefore, third, for cities with purchases from private water vendors, average water expenditures are compared for households with piped water and households purchasing from private water vendors. If water prices are higher from private water vendors than for piped water then this will be reflected in higher water expenditures (assuming inelastic water demand, as would be likely if few "free" water sources are available as substitutes for purchased water).

Of course, even if average water expenditures differ between these groups, this may reflect household heterogeneity in quantity of water demanded, not in the price. Therefore, fourth, a regression model is estimated with water expenditures as the dependent variable, controlling for household characteristics that might influence the quantity of water purchased. The demand for water is expected to increase with income. Demand for water will also increase with household size and may vary according to the characteristics of household members and the head of household. Therefore, number of children in different age groups and the sex and age of the household head is controlled for in the estimation. In addition, since the aim of the estimation is to adequately control for differences among households in the quantity demanded of water, and since for all purposes except for drinking water, household water use is essentially a derived demand for water, other housing characteristics are also controlled for in the estimation. These include having a shower or bath, having a flush toilet, and type of housing. While these housing characteristics are clearly related to income, they are also expected to have a separate influence on the quantity of water demanded by households. Since relative water prices may vary by city, city indicator variables are included in the pooled regression. In addition, the same regression specification is separately estimated for each water market. The standard errors are adjusted to account for heteroskedasticity.

The key variable of interest is the indicator for households that purchase water from private water vendors. This indicator compares water expenditures of households purchasing from vendors to households who have access to piped water in their buildings or yards, but not inside their homes. Separate indicator variables are included for households who have access to piped water inside their own homes and those who have access to piped water from a tap outside of their buildings or yards.

Last, as an example, anecdotal evidence was obtained on private vended water prices and then compared to piped water prices for the city of Cochabamba. This information is then combined with average household water expenditures to compare water spending from piped and private vended water.

Data Description

The 1994 Integrated Household Survey (EIH) of urban Bolivian households is the primary data source for this study. This is the seventh round of the EIH, which are annual surveys begun in 1988 in conjunction with the World Bank's project to promote Living Standard Measurement Study (LSMS) surveys in developing countries (Grosh and Glewwe, 1995). These surveys include both income and expenditure information as well as other social and demographic indicators of living standards. The survey is a representative sample of households in nine cities in Bolivia: Cochabamba, El Alto, La Paz, Oruro, Potosi, Santa Cruz, Sucre, Tarija, and Trinidad. This includes all of the capital cities of Bolivia except for Cobija. In addition, one city, El Alto, which is not a capital city, but is neighboring the capital city of La Paz, is included. The survey was conducted from July to December of 1994. The 1994 data is used as it allows examination of urban water provision in Bolivia in the pre-reform period. Regulatory reform at the national level was initiated in 1994 for the water, electricity, telecommunications, hydrocarbon, and transportation sectors with the first privatization of water provision occurring in 1997 (Barja and Urquiola, 2003; Nickson and Vargas, 2002). Another advantage of this survey is that the sample size is large enough to allow analysis by city. The sample size in this study is 5,793.[9]

On average households spend about 2 percent of their income on water. Average monthly household income is 1,378 bolivianos (bs.) (US$ 293), while per capita monthly income is 375 bs. (US$ 80).[10] The Lorenz curve in Figure 2 shows the distribution of income for households in the sample, reflecting the unequal distribution of income in urban Bolivia and highlighting the need for considering the distributional impacts of water reform.

Table 1 shows the percentage of households obtaining water from each water source. The majority, 55 percent, have piped water in their buildings or yards, but not inside their homes, while 26 percent of households have piped water inside their homes (a house may have more than one household, so home refers to the household's part of the house or apartment). Approximately 10 percent have access to piped water from a tap located outside of their buildings or yards. About 5 percent of households are directly obtaining water from various groundwater and surface water sources, while another 5 percent of households purchase water from private water vendors. Households only had the option to report one water source. Therefore, a household that responds to rationing of piped water by purchasing from a private water vendor would not report this secondary water source. Similarly, if a household purchases bottled drinking water separately due to quality concerns, this is not reported as a separate source in the survey. The private vended water source reported is that from tanker trucks, which may be of variable quality.

Overall, 84 percent of households have spending on water. Of the 16 percent of households (992 households total) with zero water expenditures, 251 households obtain water from "free" water sources such as wells and surface water. The others may report zero water expenditures for a variety of reasons, for example, those obtaining water from an outside tap may have free service. Of those with piped water inside their buildings or yards, 619 households report zero expenditures on water. Half of these households are renters who may have water services included in rent. Households obtaining housing from relatives (22 percent of those with zero water expenditures) or in exchange for services (12.6 percent of those with zero water expenditures) are more likely to report zero water expenditures, which again is likely to mean that they are not separately charged for their water use. Another reason for a household to report zero water expenditures may be piped water from an illegal connection, which was estimated by one source as 5-10 percent of connections in Cochabamba (Nickson and Vargas, 2002).

Actual physical consumption of water and the price paid by the household are not available from the survey.[11] Water price data from other sources cannot be matched up to households accurately when increasing block rates are used. The household unit used in the survey is not the same unit as a water connection, since multiple households often obtain water from the same connection. In addition, the Cochabamba residential rates vary by housing type and classification of households into type based on survey information would be highly inaccurate. Therefore, the focus of this study is on analyzing the available data on water expenditures and water sources. Average water prices by city are obtained from the Bolivian National Institute of Statistics to compare to the results of the estimation. In addition, specific examples comparing water prices by water source are given for the city of Cochabamba.

Equity Impact of Water Price Increases on Pre-reform Piped Water Users

Table 2 shows average water expenditures and the percentage of income spent on water by income decile for households using piped water (including all piped water users, regardless of location of tap).[12] The first two columns are household spending by household income deciles. As expected if water is a normal good, average expenditures on water increase with household income. Water expenditures as a percentage of income, on the other hand, are generally decreasing with income (the exception is the slight increase from the 6th to the 7th decile). However, ranking by household income deciles ignores differences in household size. Larger households with more working adults may have higher household income, but lower income per person. Therefore, per capita water expenditures by per capita income deciles are presented in the last two columns of Table 2. Again, spending on water increases with income. As a percentage of income, spending on water declines as per capita income increases, although the percentage is fairly constant over the middle-income range. This measurement of the static burden of price increases for households using piped water, suggests that an across the board increase in water prices would have a regressive impact, affecting low-income households more than high-income households. These results for urban Bolivia are consistent with those found by Barja and Urquiola (2003) for the four large cities in Bolivia. However, as discussed earlier, the static burden examined with pre-reform expenditures may overestimate the regressivity of across the board price increases if lower income households have more elastic price elasticities of demand.

The magnitude of the impact of large water price increases on low-income households could be fairly large. For example a price increase of 100 percent, with no change in quantity used, would be an additional 3 1/2 percent of income for the lowest per capita income category. A pricing reform accompanied by some mechanism to reduce the burden on low-income households that are already connected to piped water would reduce this regressive impact. Increasing block rates are one way to approach this issue, although as discussed earlier, they are not likely to completely ameliorate the problem.

Household Water Source by Income Decile

While across the board water price increases are likely to have a regressive impact on households using piped water pre-reform, water reform is intended to provide new water connections for those households that are not connected to piped water within their buildings or yards. If the benefits of new connections vary by income decile, then this also affects the regressivity of the water reform. In Table 3, the distribution of households is shown by income decile for the different sources of water. More than 10 percent in an income decile reflects a higher concentration of households with that water source in that income decile, while less than 10 percent in an income decile reflects a lower concentration of households with that water source in that decile.

Households with piped water inside their homes tend to be more concentrated in the upper income deciles, with 27 percent in the top income decile and only 3 percent in the bottom income decile. Those purchasing from private water vendors have fewer households in the upper three income deciles, with a larger concentration in the 3rd and 4th deciles. Overall households purchasing from private water vendors are more concentrated in the lower income deciles than households with piped water within their buildings or yards, either within or outside of their homes. Those with access to piped water from taps outside of their buildings or yards are more concentrated in the lowest three deciles than any of the other groups. Households obtaining water from wells are more concentrated in the middle-upper deciles (6^{th} and 7^{th}) and less concentrated in the upper three deciles than those with piped water. Those with water from the "free" sources such as rivers, lakes, streams, or irrigation ditches have a less regular pattern across income deciles. While a larger percentage of households is found in the bottom decile than the top decile, the households obtaining water from these "free" sources are not completely concentrated in the bottom deciles. This variation probably reflects heterogeneity in the quality, availability and convenience of water sources within this category. For example, an irrigation ditch may not always have water, while lakes may provide a more constant water source.

Since households obtaining piped water from taps outside of their buildings or yards and those purchasing from private water vendors are more concentrated in the lower income deciles, water reform with increased access to piped water would have a progressive impact. This assumes that these households would take advantage of improved access, which is likely to depend both on the explicit per unit costs and the fixed costs. The impact on households utilizing wells or surface water is not as clear, partly because the distribution of households by income decile is more difficult to categorize. Overall, if high-income households already have satisfactory water sources, then the impact of expanded piped water might be somewhat progressive. On the other hand, if low-income households would be more likely to continue using their current water sources (perhaps because of the barrier of fixed costs associated with connecting to the piped water), then the benefits to this subgroup of households of increased water access could be somewhat regressive.

Households purchasing from private water vendors are likely to prefer piped water if private vended water is more expensive than piped water. The next sections focus on these households to examine this potential benefit from piped water expansion. Unfortunately, this same comparison is not possible for households with well water or the other "free" sources of water with zero explicit water expenditures since their opportunity costs for obtaining water are not known.

Water from Vendors: Comparing Average Water Expenditures

As seen in the previous section, households purchasing from private water vendors have lower income, particularly relative to households with piped water inside their homes. To examine the benefit to households purchasing water from private water vendors of obtaining a piped water connection, average water expenditures are compared for households obtaining piped water to those purchasing from private water vendors. Households in four of the nine cities are observed to purchase from private water vendors.[13] Therefore, to make the expenditure comparisons more relevant, only households in these four cities (Sucre, La Paz, El Alto, and Cochabamba) are included in the analysis. Water sources for households in these cities are shown in Figure 3. Cochabamba stands out with the highest percentage (over 20 percent) obtaining water from private water vendors.

As in the analysis of water expenditures by income category, households with zero expenditures on water are excluded from the analysis. For these four cities, 13 percent of the households (445 households) reported zero water expenditures. Of these 445 households, 133 obtained water from wells, surface water, or other sources (not piped water or private vended water) and were not asked to report water expenditures since these are generally "free" sources. Including the households with zero water expenditures would not contribute to the analysis since they do not provide any additional information on the difference between piped water and private vended water expenditures.

On average, households purchasing from private water vendors have lower monthly water spending than those obtaining piped water within their homes, but higher monthly water spending than those with piped water outside their homes, but within their buildings or yards (Table 4). This holds true whether looking at household water expenditures or per capita water expenditures. Since average income of households purchasing from private water vendors is lower than for those obtaining piped water inside their homes, these households probably use less water on average, so the lower spending may reflect a lower quantity rather than lower water prices. A better comparison, given the relative similarity of income levels, is between households purchasing from private water vendors and households with piped water outside their homes, but within their buildings or yards. In this case, those purchasing from private water vendors spend 18.22 bs. per month, which is 5.50 bs. per month more than the 12.72 bs. spent by those with piped water outside their homes, but within their buildings or yards. Assuming that households purchasing from vendors use either a similar amount or less water, this observed difference in water spending is consistent with higher prices for private vended water than for piped water.

Water from Private Water Vendors: Regression Results

The comparison of average water expenditures in the previous section does not take into account other household differences that might affect the quantity of water purchased. For this reason, a similar comparison of water spending is done in a regression framework, controlling for a variety of additional variables that may affect the quantity of water used. Again, the households included are those from cities with purchases from private water vendors (La Paz, El Alto, Cochabamba, and Sucre). The means of the relevant variables are in Table 5, for the four cities together, and separately for each water market. The first column in Table 6 shows regression results for all four cities combined, controlling for city differences with indicator variables. The parameter estimate on the indicator variable for households purchasing from private water vendors is positive and shows that on average they spend 4.20 bs. more per month on water than households with access to piped water within their buildings or yards, but not inside their homes (the indicator variable for these households is the omitted category in the regression). The estimated parameters suggest that households purchasing from private water vendors are also spending more than those with piped water inside their homes, however, the difference is not statistically significant. This evidence is also consistent with households purchasing from private water vendors paying higher per unit prices for water than households with piped water. This suggests that households purchasing from private water vendors might be better off with a water reform that includes increased access to piped water.

Examining the other parameter estimates, households with piped water from a tap outside of their buildings or yards are found to spend 4.96 bs. less per month than those with piped water outside of their homes, but inside their buildings or yards. Since this relates to cash expenditures, this does not imply that opportunity costs are lower, as time spent obtaining water is not accounted for.

Water spending increases with household income, although at a slightly declining rate, as seen by the positive parameter estimate on the linear term for household income and the negative estimated parameter on the quadratic term (only the parameter estimate on the linear term is statistically significant). However, the small magnitude of the parameter estimates implies an inelastic income elasticity of demand. When calculated at the sample means for income and water expenditures, the income elasticity is 0.26.

Water spending also increases with household size, although at a decreasing rate, since the parameter estimate on the quadratic term is negative (although not statistically significant), suggesting economies of scale with household water use. Having a private flush toilet, or a shower or bathtub, increases water expenditures. By housing type, those in apartments spend the most on water, then those in houses, followed by those in rooms or informal housing.[14] It is not surprising that those in rooms or informal housing would spend the least of these three categories since some water use will be dependent on the size of living quarters and yard space (e.g. for cleaning or watering purposes). Households that neither own nor rent their housing, but have housing given to them either in exchange for services or from a relative, may not be paying the full cost of the water services that they receive.[15] However, neither of the parameter estimates for these ways of obtaining housing are significantly different from zero.

The parameter estimates on indicator variables for number of children in three different age categories and for female household heads are not significantly different from zero. However, older household heads spend more on water than do younger household heads, although the implied magnitude of the parameter estimate of 0.084 bs. increase per year of age is small.

The parameters on city indicator variables are likely to reflect differences in water prices, as well as geographic differences in water use. Relative to the omitted category of El Alto, households in the valley cities of Sucre and Cochabamba spend more on water, while those in La Paz do not spend a significantly different amount than those in El Alto. This latter makes sense since La Paz and El Alto are neighboring cities served by the same water company, with the same piped water prices. Also, looking at average water prices by city in Figure 4, in 1994, Cochabamba had a higher average price than Sucre, which had a higher average price than La Paz, a ranking which is consistent with the estimated city parameters in the regression.[16]

Since relative prices of both water from private water vendors and piped water may vary by city, the same regression specification is also estimated for these three water markets separately. The results for Cochabamba are in Column 2, for La Paz and El Alto in Column 3, and for Sucre in Column 4 (Table 6). The main result that stands out is that the difference between spending by those purchasing from private water vendors and those with piped water outside of their homes, but inside of their buildings or yards is 7.29 bs. per month in Cochabamba, a larger difference than in the pooled regression. The estimated parameter on those purchasing from private water vendors is also greater than those purchasing piped water inside their homes, although as before, the difference is not statistically different from zero. However, looking at the other cities, in La Paz and El Alto, water spending by those purchasing from private water vendors is statistically indistinguishable from those purchasing piped water outside of their homes, but inside of their buildings or yards, while in Sucre they actually are spending less per month. However, at least in Cochabamba, increased access to piped water would appear to be beneficial to households purchasing from private water vendors.

The results for the other parameter estimates are similar to those in the pooled regression. However, for Sucre, households obtaining housing in exchange for services spend significantly less on water than other households, while those obtaining housing from a relative spend more on water than other households.[17] In the separate city regressions the parameter estimate on household size is not statistically significant, even at the 10 percent significance level. In La Paz/El Alto and Sucre, spending does not differ significantly by housing type.

The regression analysis provides some evidence that households purchasing from private water vendors pay higher prices per unit of water than households with piped water. In comparison to households with piped water outside of their homes, but in their buildings or yards, those purchasing from private water vendors spend more on average, although this result is strongest for the city of Cochabamba and may not be the case in the other three cities.

Water Price Comparisons for Cochabamba

In the previous section, the largest differences in spending between households purchasing private vended water and those with piped water are found in the city of Cochabamba. As an example, in this section, private vended water prices are compared to the tariffs for piped water in Cochabamba in 1994. Reported prices per barrel of water (about 200 liters) ranged from 2 to 5 bs., which corresponds to 10-25 bs. per m^3, although during October 1994 some free distribution of water by truck did occur to compensate for water shortages experienced by households in peripheral neighborhoods (*Opinion,* Oct. 4, 1994, “Cordeco distribuirá desde mañana agua potable gratis en cisternas."; *Opinion,* Sept. 25, 1994, "Precio del turril de agua incrementaron en 150%").[18] Assuming the lower price of 10 bs. per m^3, the average water expenditures of 22.88 bs. per month for those purchasing from private water vendors in Cochabamba in this sample, corresponds to an average water usage of 2.3 m^3 per month. Note that 2.3 cubic meters corresponds to about 19 liters per person per day (based on 30 days per month and average of 4 people per household). This is low relative to the estimated 25-50 liters per capita per day usually considered as essential (Whittington, 1992).

For households using piped water, the price for the first 12 m^3 averages about 1.15 bs. per m^3 (with a marginal price of zero) while from 13-25 m^3 the marginal price is 0.48 bs. At these rates, 17 m^3 of water would cost 16.24 bs., close to the average water spending of 16.34 bs. by households with piped water outside of their homes, but inside their buildings or yards in Cochabamba.[19] The average price in this example is 0.96 bs. per m^3. This comparison suggests that households in Cochabamba purchasing private vended water pay higher prices and consume less water.

Residential rates for a household in the economical housing category (R3) were used in this calculation, excluding sewerage charges. In December 1994, 42 percent of residential water connections in Cochabamba were in this category (R3), while 33 percent of connections were in R2 (lowest quality housing), 21 percent of connections were in the highest priced residential category (R4), and 4 percent of residential connections were in R1 (empty lots) (Barragán et al., 1998). This calculation also assumes the household is subject to the statutory water rate schedule, which is not accurate when multiple households share a water meter or if a household has no water meter and pays a fixed amount.

Conclusions

For households using piped water, low-income households are found to spend a higher percentage of their income on water than do high-income households. This static burden measure suggests that across the board water price increases would have a regressive impact. This aspect of household water use is the usual basis of equity arguments against increasing water prices. It is also the reason usually given for the persistence of the "low-level equilibrium trap" described by Walker et al. (1999), where water systems are unable to expand services due to lack of funding while current users receive water at below the marginal costs of provision. However, examining only this static burden does not take into account that price elasticities of demand may vary by income. If low-income households have more elastic price elasticities of demand then this would reduce the regressivity of water price increases. Water tariff structures may also be designed to reduce the regressivity of price increases. Increasing block tariffs can reduce the impact of price increases on low income households, although imperfectly since low-income households may not also be low water users, particularly if multiple households share a single water meter.

In addition, only considering households using piped water pre-reform ignores the potential benefits of water reform for households without access to piped water within their buildings or yards, about nineteen percent of households in these urban areas of Bolivia. Households purchasing from private water vendors are found to be poorer on average than households with piped water inside their buildings or yards, yet they spend more on average on water, after controlling for other factors. Therefore, the equity arguments used to keep the price of water low do not help these low-income households, rather they continue to be negatively impacted by the “low-level equilibrium trap” and lack of expansion of piped water access. Since households purchasing from private water vendors are concentrated in the bottom 50 percent of the income distribution, this would make a water reform more progressive. Regression analysis shows that, on average, households that purchase from private water vendors spend more on water than those getting piped water, and this difference is particularly striking for the city of Cochabamba. Comparing prices of piped and private vended water in the city of Cochabamba also showed private vended water to be more expensive per unit. These results are similar to findings in other countries where low-income households without water connections pay higher water prices than those with connections. While it is difficult to categorize the impact for households obtaining water from “free” sources of water or from outside taps without knowing more about either the quality or implicit costs associated with these water sources, some of these households also are likely to benefit from increased access to piped water.

Another benefit from water reform which could not be quantified with available data is reduced rationing and improved service for households with access to piped water pre-reform. Further research in this area may find that low-income households would benefit more from service improvements and reduced water rationing than high-income households that had already alleviated the impact of rationing by installing large water storage tanks. Further research into the implicit costs involved in water provision and the quality of water for those obtaining water from “free” sources or outside taps might also show additional benefits from improving and expanding piped water systems that also could not be quantified with available data.

In conclusion, to understand the equity impact of water reform the effects on both pre-reform users of piped water and those without access to piped water must be considered. While unserved households would benefit from increased piped water access, when water system expansion is linked to increased water prices, piped water users may resist these price increases, as seen in Cochabamba, Bolivia in 2000. Paradoxically, these equity concerns may lead to the continuation of the "low-level equilibrium trap" with low-income households disproportionately bearing the burden of reduced access to piped water.

References

Agthe, Donald E.; Billings, R. Bruce. "Equity, Price Elasticity, and Household Income under Increasing Block Rates for Water." *American Journal of Economics and Sociology*, 46, 3, 1987, pp. 273-286.

Asthana, Anand N. "Where the Water is Free but the Buckets are Empty: Demand Analysis of Drinking Water in Rural India,"*Open Economies Review*, 8, 2, 1997, pp. 137-149.

Ballvé, Marcelo. "Bolivia: Privatized Water Company Defeated." *NACLA Report on the Americas*, 38, 5, March/April 2005, p. 41-43.

Barja, Gover; Urquiola, Miguel. "Capitalization, Regulation, and the Poor: Access to Basic Services in Bolivia." in *Utility Privatization and Regulation: A Fair Deal for Consumers?* Cecilia Ugaz and Catherine Waddams Price, editors. Edward Elgar: UK, 2003.

Barragán, Julio; Crespo, Carmen; Donoso, Guillermo; Escobar, Jairo. *Mercados e Instituciones de Aguas en Bolivia.* UDAPE (UNIDAD DE ANALISIS DE POLITICAS SOCIALES Y ECONOMICAS), La Paz, Bolivia, 1998.

Briscoe, John; Furtado de Castro, Paulo; Griffin, Charles; North, James; Olsen, Orjan. "Toward Equitable and Sustainable Rural Water Supplies: A Contingent Valuation Study in Brazil," *The World Bank Economic Review*, 4, 2, 1990, pp.115-134.

Brookshire, David S.; Whittington, Dale. "Water Resources Issues in the Developing Countries," *Water Resources Research*, 29, 7, 1993, pp. 1883-1888.

Cairncross, Sandy; Kinnear, Joanne. "Elasticity of Demand for Water in Khartoum, Sudan," *Soc. Sci. Med.*, 34, 2, 1992, pp. 183-189.

Clarke, George R. G.; Menard, Claude; Zuluaga, Ana Maria. "Measuring the Welfare Effects of Reform: Urban Water Supply in Guinea." *World Development*, 30, 9, 2002, pp. 1517-1537.

Dinar, Ariel, ed. *The Political Economy of Water Pricing Reforms*. Oxford University Press: New York, 2000.

Esrey, Steven A. "Water, Waste, and Well-Being: A Multicountry Study." *American Journal of Epidemiology* 143, 6, 1996, p. 608-623.

Esrey, S.A.; Potash, J.B.; Roberts, L.; Shiff, C. "Effects of Improved Water Supply and Sanitation on Ascariasis, Diarrhoea, Dracunculiasis, Hookworm Infection, Schistosomiasis, and Trachoma." *Bulletin of the World Health Organization* 69, 5, 1991, pp. 609-621.

Estache, Antonio; Gomez-Lobo, Andres; Leipziger, Danny. "Utilities Privatization and the Poor: Lessons and Evidence from Latin America," *World Development* 29, 7, 2001, pp. 1179-1198.

Farthing, Linda; Kohl, Ben. "Bolivia's New Wave of Protest," *NACLA Report on the Americas*, 34, 5, March/April 2001, pp. 8-11.

Finnegan, William. "Leasing the Rain," *The New Yorker*, April 8, 2002, pp. 43-53.

Foster, Vivien, editor. *Condominial water and sewerage systems-costs of implementation of the model: an economic and financial evaluation of El Alto Pilot Project in Bolivia.* UNDP-Water and Sanitation Program, Report 24653, 2001.

Galindo, Luis Miguel. "La demanda de agua potable en México: Estimaciones Preliminares." *Investigación Económica*, 59, 227, 1999, pp. 27-43.

Gómez-Lobo, Andrés; Foster, Vivien; Halpern, Jonathan. "Better Household Surveys for Better Design of Infrastructure Subsidies," *Viewpoint,* No. 213, The World Bank Group, Private Sector and Infrastructure Network, Washington, DC: World Bank, June 2000.

Grosh, Margaret E.; Glewwe, Paul. *A Guide to Living Standards Measurement Study Surveys and Their Data Sets*, Living Standards Measurement Study Working Paper No. 120, Washington, DC: World Bank, 1995.

Hutton, Guy and Haller, Laurence. *Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level*, Geneva: World Health Organization, 2004.

IMF (International Monetary Fund). *International Financial Statistics Yearbook 2003.*

Komives, Kristin. *Designing Pro-Poor Water and Sewer Concessions: Early Lessons from Bolivia*, Policy Research Working Paper No. 2243, Private Sector Development Department, Private Participation in Infrastructure, Washington, DC: World Bank, November 1999.

Komives, Kristin; Foster, Vivien; Halpern, Jonathan; Wodon, Quentin. *Water, Electricity, and the Poor: Who Benefits from Utility Subsidies?* Washington, DC: World Bank, 2005.

McPhail, Alexander A. "Why Don't Households Connect to the Piped Water System? Observations from Tunis, Tunisia," *Land Economics*, 70, 2, pp. 189-96.

Marvin, Simon and Laurie, Nina. "An Emerging Logic of Urban Water Management, Cochabamba, Bolivia," *Urban Studies*, 36, 2, 1999, pp. 341-357.

McKenzie, David and Mookherjee, Dilip. *The Distributive Impact of Privatization in Latin America: Evidence from Four Countries*. Boston University, Institute for Economic Development Discussion Paper No. 128, Feb. 2003.

Nickson, Andrew and Vargas, Claudia. “The Limitations ofWater Regulation: The Failure of the Cochabamba Concession in Bolivia.” *Bulletin of Latin American Research* 21, 1, 2002, pp. 99-120.

North, J.H.; Griffin, C.C. “Water Source as a Housing Characteristic: Hedonic Property Valuation and Willingness to Pay for Water,” *Water Resources Research*, 29, 7, July 1993, pp. 1923-1929.

Plummer, Mary L. “To Fetch a Pail of Water.” *Natural History*, 108, 1, 1999, pp. 56-65.

Rietveld, Piet. “Block Rate Pricing of Water in Indonesia: An Analysis of Welfare Effects,” *Bulletin of Indonesian Economic Studies*, 36, 3, 2000, pp. 73-92.

Schultz, Jim. “Bolivia’s Water War Victory,” *Earth Island Journal Online*, 15, 3, Fall 2000, www.earthisland.org.

Shirley, Mary M. *Thirsting for Efficiency: The Economics and Politics of Urban Water System Reform*. World Bank: Washington, DC, 2002.

Solo, Tova Maria. “Competition in Water and Sanitation: The Role of Small-Scale Entrepreneurs.” *Viewpoint* No.165, Finance, Private Sector, and Infrastructure Network. World Bank: Washington, DC, December 1998.

Spronk, Susan; Webber, Jeffery R. “The Two Bolivias Square Off.” *Canadian Dimension* 39, 3, May/Jun 2005, p. 17-19.

Timmins, Christopher. “Does the Median Voter Consume Too Much Water? Analyzing the Redistributive Role of Residential Water Bills.” *National Tax Journal*, 55, 4, 2002, p. 687-702.

Walker, Ian; Ordoñez, Fidel; Serrano, Pedro; Halpern, Jonathan. “Pricing, Subsidies, and the Poor: Demand for Improved Water Services in Central America.” *Policy Research Working Paper* No. 2468, Finance, Private Sector, and Infrastructure Sector Unit, Latin American and the Caribbean Region, World Bank: Washington, DC, November 2000.

Walker, Ian; Velasquez, Max; Ordoñez, Fidel; Rodriguez, Florencia. “Reform Efforts in the Honduran Water Sector.” in *Spilled Water: Institutional Commitment in the Provision of Water Services* eds. William D. Savedoff and Pablo T. Spiller, Inter-American Development Bank: Washington, DC, 1999.

Whittington, Dale. “Possible Adverse Effects of Increasing Block Water Tariffs in Developing Countries,” *Economic Development and Cultural Change*, 41, 1, 1992, p. 75-87.

Whittington, Dale; Lauria, Donald T.; Mu, Xinming. “A Study of Water Vending and Willingness to Pay for Water in Onitsha, Nigeria,” *World Development*, 19, 2/3, 1991, pp. 179-198.

Zeballos Hurtado, Hernán and Eduardo Quiroga Crespo. *Política y economía de los recursos naturales renovables en Bolivia*. Plural editores: La Paz, Bolivia, 2003.

World Bank Operations Evaluation Department. “Bolivia Water Management: A Tale of Three Cities,” *Précis* No. 222, World Bank: Washington, DC, Spring 2002.

Table 1. Source of Household Water (Population Weighted Percentage of Households)	
Source of Water	Percentage of Households
Piped Water Within Home	25.79
Piped Water Outside of Home, Within House, Building or Yard	54.77
Piped Water from Tap Outside of House, Building or Yard	9.75
Purchase from Private Water Vendors	5.06
Well	3.40
River, Lake, Stream, Irrigation Ditch	1.17
Other	0.06
Total	100.0
Sample Size	N=5,793
Source: Author's calculations from 1994 Bolivian Integrated Household Survey	

Table 2. Water Expenditures for Current Piped Water Users by Household Income or Per Capita Income Decile (population weighted means with standard errors in parentheses)

	Household Water Expenditures		Per Capita Water Expenditures	
Deciles	Water Expenditures (bs./month) Mean (s.e.)	Water Expenditures as a Percentage of Income Mean (s.e.)	Per Capita Water Expenditures (bs./month) Mean (s.e.)	Water Expenditures as a Percentage of Income Mean (s.e.)
1	7.53 (0.45)	3.75 (0.21)	1.84 (0.10)	3.52 (0.20)
2	7.89 (0.39)	2.06 (0.10)	2.03 (0.11)	2.10 (0.12)
3	10.38 (0.58)	2.07 (0.12)	2.34 (0.13)	1.83 (0.10)
4	12.04 (0.60)	1.86 (0.09)	2.95 (0.16)	1.81 (0.10)
5	13.38 (0.66)	1.70 (0.08)	3.37 (0.16)	1.67 (0.08)
6	13.77 (0.64)	1.45 (0.07)	4.01 (0.22)	1.64 (0.09)
7	18.63 (0.99)	1.55 (0.08)	4.84 (0.23)	1.58 (0.08)
8	18.50 (0.81)	1.19 (0.05)	5.50 (0.35)	1.39 (0.09)
9	25.52 (1.03)	1.15 (0.05)	6.93 (0.30)	1.21 (0.05)
10	44.27 (2.01)	0.88 (0.03)	12.91 (0.65)	0.92 (0.04)
Total	17.47 (0.33)	1.75 (0.03)	4.77 (0.10)	1.75 (0.03)
Sample Size	N=5,247	N=5,247	N=5,247	N=5,247

[1]Income deciles are population weighted deciles for the entire sample for either per capita or household income.
Source: Author's calculations from 1994 Bolivian Integrated Household Survey

Table 3. Percentage of Households in Income Decile by Water Source						
Income Deciles[1]	Piped Water Sources			Non-piped Water Sources		
	Within Home	Within House, Building, or Yard, outside of home	Outside of House, Building, or Yard	Purchase from Private Water Vendors	Well	River, Lake, Stream, Irrigation Ditch
1	3.45	11.73	16.51	12.96	10.38	5.6
2	3.94	10.99	17.44	10.91	9.52	10.27
3	4.27	11.64	13.73	17.18	11.66	5.35
4	5.82	11.57	10.55	14.72	10.4	16.84
5	7.46	10.63	8.65	12.46	10.27	12.36
6	6.84	11.42	11.66	9.28	15.61	14.44
7	10.06	10.36	7.1	6.93	12.96	9.51
8	12.79	9.94	6.92	6.59	8.39	9.09
9	17.93	7.46	5.43	4.79	6.67	14.01
10	27.44	4.27	2.01	4.2	4.15	2.54
All deciles	100	100	100	100	100	100
Sample Size	N=1,532	N=3,155	N=560	N=295	N=180	N=67

[1] Income deciles are population weighted deciles for the entire sample.
"Other" category not listed due to limited number of households (N=4)
Source: Author's calculations from 1994 Bolivian Integrated Household Survey

Table 4. Monthly Water Expenditures, Income and Household Size by Water Source for Households in Sucre, Cochabamba, El Alto and La Paz
Means with Standard Errors in Parentheses (population weighted)

	Purchase from Private Water Vendors	Piped Water Within Home	Piped Water Outside of Home, Within House, Building, or Yard	Piped Water Outside of House, Building, or Yard
Water Spending (bs./mo.)	18.22 (1.08)	28.11 (0.76)	12.72 (0.29)	4.36 (0.23)
Per capita Water Spending (bs./mo.)	4.68 (0.40)	8.77 (0.34)	3.65 (0.10)	1.07 (0.06)
Household Income (bs./mo.)	927.72 (61.00)	2,214.22 (71.72)	1,046.72 (28.99)	801.06 (41.30)
Per capita Household Income (bs./mo.)	250.50 (37.92)	683.49 (31.68)	284.65 (10.81)	182.18 (9.77)
Household Size	4.56 (0.12)	4.16 (0.07)	4.35 (0.05)	4.91 (0.13)
Sample Size[1]	N=293	N=861	N=1,503	N=299

[1] Includes cities with purchases from private water vendors of Sucre, Cochabamba, La Paz and El Alto. Households with zero water expenditures are excluded.
Source: Author's calculations from 1994 Bolivian Integrated Household Survey

Table 5. Household Characteristics for Households in Sucre, Cochabamba, El Alto and La Paz
(Population weighted means with standard errors in parentheses)

Variable	4 Cities together	Cochabamba	La Paz/ El Alto	Sucre
Water Expenditures (bs./month)	16.63 (0.32)	23.60 (0.672)	14.09 (0.366)	18.68 (1.139)
Purchase from Private Water Vendors[1]	0.095 (0.005)	0.233 (0.014)	0.053 (0.005)	0.057 (0.014)
Piped Water from Outside of House, Building or Yard[1]	0.111 (0.006)	0.020 (0.005)	0.147 (0.008)	0.064 (0.015)
Piped Water Inside House, Building or Yard, outside home[1]	0.513 (0.009)	0.417 (0.017)	0.543 (0.012)	0.528 (0.031)
Piped Water Inside Home[1]	0.281 (0.008)	0.330 (0.016)	0.258 (0.010)	0.351 (0.030)
Household Income (bs. per month)	1,335.91 (28.24)	1,291.66 (47.374)	1,377.26 (37.789)	1,064.99 (64.984)
Shower or bath[1]	0.414 (0.009)	0.463 (0.017)	0.373 (0.011)	0.662 (0.030)
Private Flush Toilet[1]	0.296 (0.008)	0.317 (0.016)	0.277 (0.010)	0.420 (0.031)
Rooms[1]	0.517 (0.009)	0.513 (0.017)	0.521 (0.012)	0.487 (0.031)
Apartment[1]	0.116 (0.006)	0.087 (0.010)	0.128 (0.008)	0.088 (0.018)
House[1]	0.367 (0.009)	0.399 (0.017)	0.351 (0.011)	0.425 (0.031)
Housing Exchanged for Services[1]	0.029 (0.003)	0.028 (0.006)	0.032 (0.004)	0.003 (0.004)
Housing Obtained from Relative[1]	0.170 (0.007)	0.154 (0.012)	0.181 (0.009)	0.104 (0.019)
Number of Children Under 6	0.643 (0.016)	0.657 (0.030)	0.640 (0.020)	0.632 (0.056)
Number of Children 6 to 12	0.730 (0.017)	0.724 (0.031)	0.725 (0.022)	0.804 (0.061)
Number of Teenagers (13-18)	0.617 (0.016)	0.622 (0.031)	0.615 (0.021)	0.621 (0.050)
Household Size	4.380 (0.038)	4.410 (0.071)	4.368 (0.047)	4.396 (0.147)
Female Head of Household[1]	0.179 (0.007)	0.212 (0.014)	0.162 (0.009)	0.239 (0.027)
Age of Household Head	42.7 (0.261)	43.617 (0.506)	42.515 (0.322)	41.388 (0.974)
Sample Size [2]	N=2,956	N=874	N=1,825	N=257

[1] Indicator variables; 1 if have characteristic, 0 otherwise.
[2] Excludes households with zero water expenditures.
Source: Author's calculations from 1994 Bolivian Integrated Household Survey

Table 6. Water Expenditures Regression Results, Parameter Estimates with Standard Errors in Parentheses (continued on next page)

Variable Description	4 cities together	Cochabamba	La Paz & El Alto	Sucre
Purchase from Private Water Vendors[1]	4.20*** (1.08)	7.29*** (1.55)	1.47 (1.55)	-3.87** (1.75)
Piped Water Inside Home[1]	3.65*** (0.98)	3.86* (2.31)	3.04*** (1.22)	6.96*** (2.75)
Piped Water from Outside of House, Building or Yard[1]	-4.96*** (0.47)	-6.31*** (1.83)	-5.57*** (0.48)	-3.15 (1.96)
Household Income (bs. per month)	0.003*** (0.001)	0.003*** (0.001)	0.004*** (0.001)	0.007** (0.003)
Household Income (bs. per month) squared	-8.26e-08 (6.14e-08)	-7.42e-08 (6.12e-08)	-8.76e-08 (1.38e-07)	-7.76e-07* (4.30e-07)
Shower or bath[1]	3.22*** (0.70)	5.55*** (1.56)	2.08*** (0.79)	4.17* (2.19)
Private Flush Toilet[1]	5.61*** (1.05)	5.25** (2.52)	4.87*** (1.23)	5.59** (2.35)
Apartment[1]	4.50*** (1.49)	10.50*** (3.60)	2.68 (1.71)	5.55 (6.10)
House[1]	1.21** (0.54)	3.12*** (1.19)	0.16 (0.61)	2.76 (1.91)
Housing Exchanged for Services[1]	1.68 (1.66)	0.72 (2.18)	2.85 (2.23)	-8.44*** (2.82)
Housing Obtained from Relative[1]	0.72 (0.59)	0.07 (1.31)	0.33 (0.67)	5.49* (2.93)
Number of Children Under 6	-0.45 (0.49)	-0.12 (0.96)	-0.27 (0.60)	-1.59 (1.85)
Number of Children 6 to 12	-0.56 (0.43)	-1.02 (0.91)	-0.11 (0.53)	-0.71 (1.31)
Number of Teenagers (13-18)	0.16 (0.48)	1.07 (1.01)	0.02 (0.55)	-1.86 (1.54)
Household Size	0.96* (0.50)	1.49 (1.12)	0.42 (0.57)	1.78 (1.41)
Household Size Squared	-0.020 (0.040)	-0.099 (0.079)	0.019 (0.047)	-0.004 (0.102)
Female Head of Household	0.34 (0.76)	1.00 (1.70)	0.13 (0.80)	1.02 (2.23)
Age of Household Head	0.084*** (0.023)	0.148*** (0.042)	0.061** (0.030)	0.002 (0.072)

*Significant at 10% significance level
**Significant at 5% significance level
***Significant at 1% significance level
[1]Indicator variables; 1 if have characteristic, 0 otherwise.
Standard errors adjusted for heteroskedasticity.
Data Source: 1994 Bolivian Integrated Household Survey

Table 6. Water Expenditures Regression Results, Parameter Estimates with Standard Errors in Parentheses (continued from previous page)

Variable Description	4 cities together	Cochabamba	La Paz & El Alto	Sucre
La Paz[2]	-0.72 (0.57)		-0.27 (0.54)	
Sucre[2]	2.76*** (1.04)			
Cochabamba[2]	7.18*** (0.71)			
Constant	-1.15 (1.37)	-0.19 (2.85)	1.67 (1.64)	-1.56 (4.03)
Sample Size	2,956	874	1,825	257
R^2	0.37	0.29	0.39	0.34
Standard Error of Regression	13.92	16.56	12.10	15.16

*Significant at 10% significance level
**Significant at 5% significance level
***Significant at 1% significance level
[2]City Indicator variables.
Standard errors adjusted for heteroskedasticity.
Data Source: 1994 Bolivian Integrated Household Survey

Appendix Table A. Residential Water Tariff Structures for Aguas del Illimani and Aguas del Tunari

Aguas del Illimani La Paz/El Alto May 1997 ($ US)		Aguas del Tunari Cochabamba November 1999 ($ US)				
m^3/month	$US/$m^3$	m^3/month	Empty lots	“Precarious” housing	“Economic” dwellings	Luxury housing
1 - 30	0.2214	Flat fee up to 12	1.80	3.02	4.85	8.64
31-150	0.4428	13-25	0.153	0.288	0.394	0.518
151-300	0.6642	26-50	0.180	0.307	0.422	0.557
301 +	1.1862	51-100	0.271	0.326	0.432	0.624
		101-150	0.361	0.361	0.538	0.768
		> 150	0.379	0.379	0.541	0.768

Sources: Cochabamba, Nickson and Vargas (2002), Table 3, p. 109
La Paz/El Alto, Barja and Urquiola (2003), Table 17, p. 37

Endnotes

1.Zeballos Hurtado and Quiroga Crespo (2003) compare average water prices with average water costs for seven Bolivian water companies regulated by the Superintendent of Basic Sanitation and find that in four cases average operating cost is greater than average price, evidence that the "low-level equilibrium trap" exists in Bolivia.

2.For additional reading on water reforms in developing countries see Dinar (2000) and Shirley (2002).

3.These data were obtained from the Bolivian National Institute of Statistics (INE).

4.For more reading on the situation in Cochabamba see Farthing and Kohl, 2001, Finnegan, 2002, Marvin and Laurie,1999 or Nickson and Vargas, 2002. The website for one of the stakeholders in Aguas de Tunari (the company granted the water concession in Cochabamba) also provides an accounting from their perspective (www.bechtel.com).

5.The water company in Santa Cruz (SAGUAPAC) has been functioning as a cooperative since 1979 (Nickson and Vargas, 2002).

6.On its website (www.bechtel.com), Bechtel (a majority holder in International Water which in turn had majority holdings in Aguas del Tunari), documents the range of monthly invoices by category, showing smaller percentage increases when comparing the ranges of expenditures in any given category for the categories that are intended to capture lower income households. By contrast the Democracy Center, a group highly critical of Bechtel and the water privatization, published figures on their website (www.democracyctr.org) from a study by SEMAPA, the public water company, which compared the tariff structure holding water quantity in a user category constant and showed percentage increases of 43 percent on the poorest residential category, 40 percent on the economical housing residential category and 57 percent for the highest residential category.

7.See Estache et al., 2001 and McKenzie and Mookherjee, 2003 for analysis of the impact of privatization in Latin America.

8.They also report on a convergence in connection rates by income in 1999 for all cities combined. However, since they combine cities which experienced reform with those that did not experience reform it is difficult to see what the comparison of 1994 to 1999 connection rates implies. The 1999 survey data is from the Encuesta Continua de Hogares, which was national in focus, but has a much smaller sample size for urban areas (they report a sample size of 1,324) so it probably would have been difficult for them to break the analysis down further by city.

9. Data are available for 6,268 households, however, 164 were later assigned zero weights by INE because they were located outside of official city limits. Sample size for this study is smaller primarily due to households with missing income information. In addition, one household with extremely high water spending was omitted as it appeared to be either a mistake or a household with commercial water use.

10.Throughout this paper survey information is given in the Bolivian currency, bolivianos. US dollars are given here for comparison.

11.See Gómez-Lobo et al. (2000) on improving LSMS surveys to include more usable information on the water sector.

12.Households obtaining piped water from a tap outside of their house, building, or yard are included in this analysis since they would also likely be affected by price increases. However, this category of piped water is not necessarily subject to the same type of pricing as that obtained within the house, building or yard. When the same analysis is conducted with only households with piped water inside their house, building, or yard, the same conclusions are reached about the distribution of water expenditures by income decile.

13.Actual use of private water vendors may be underestimated somewhat, since private vended water purchases as a secondary water source are not reported in these data. In addition, peripheral areas may be excluded if they are outside of official city limits, possibly under-representing the population without piped water who may purchase from private water vendors.

14. Since only one household had informal housing, it is included with the rooms category.

15.Households that own or rent include those with mixed contracts or “anticrético” where tenants give a large upfront payment to the owner which is returned to them upon leaving.

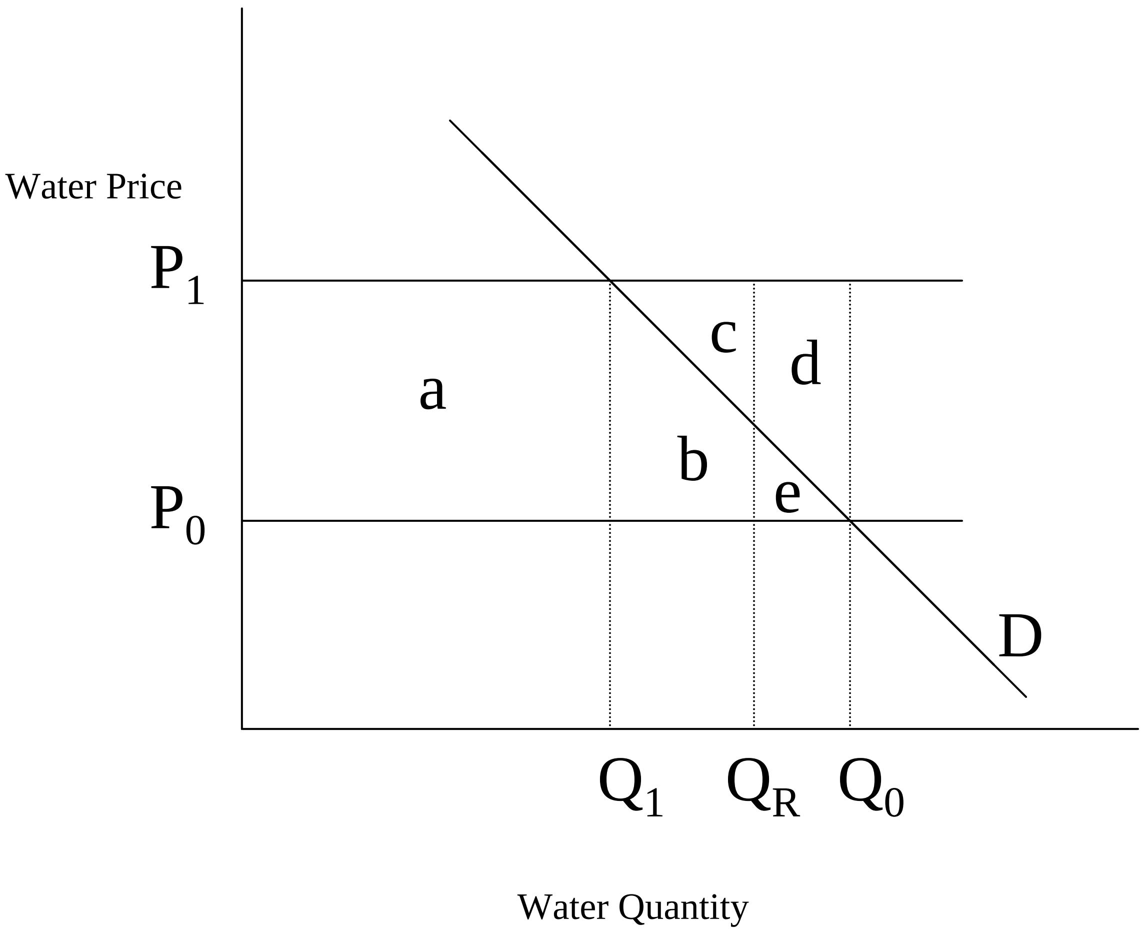
16.These average prices are calculated by dividing total residential water expenditures by total residential water consumption. The data were obtained from the Bolivian National Institute of Statistics (www.ine.gov.bo).

17.The regressions are also duplicated using per capita water expenditures and per capita income with similar results. However, for Sucre, the finding that those purchasing from private water vendors are spending less is no longer statistically significant.

18.Newspaper articles were obtained from the CEDIB (Centro de documentación e información) newspaper database in Cochabamba, Bolivia.

19.These tariffs were obtained for piped water in Cochabamba in December 1993 from the water company in Cochabamba (SEMAPA Planning Department mimeograph). Assuming tariffs remained constant in US dollars, these are converted to December 1994 rates using end of year exchange rates which increased from 4.475 bs. per $ US to 4.695 bs. per $ US (IMF, 2003).

Figure 1. Welfare Effects of a Water Price Increase



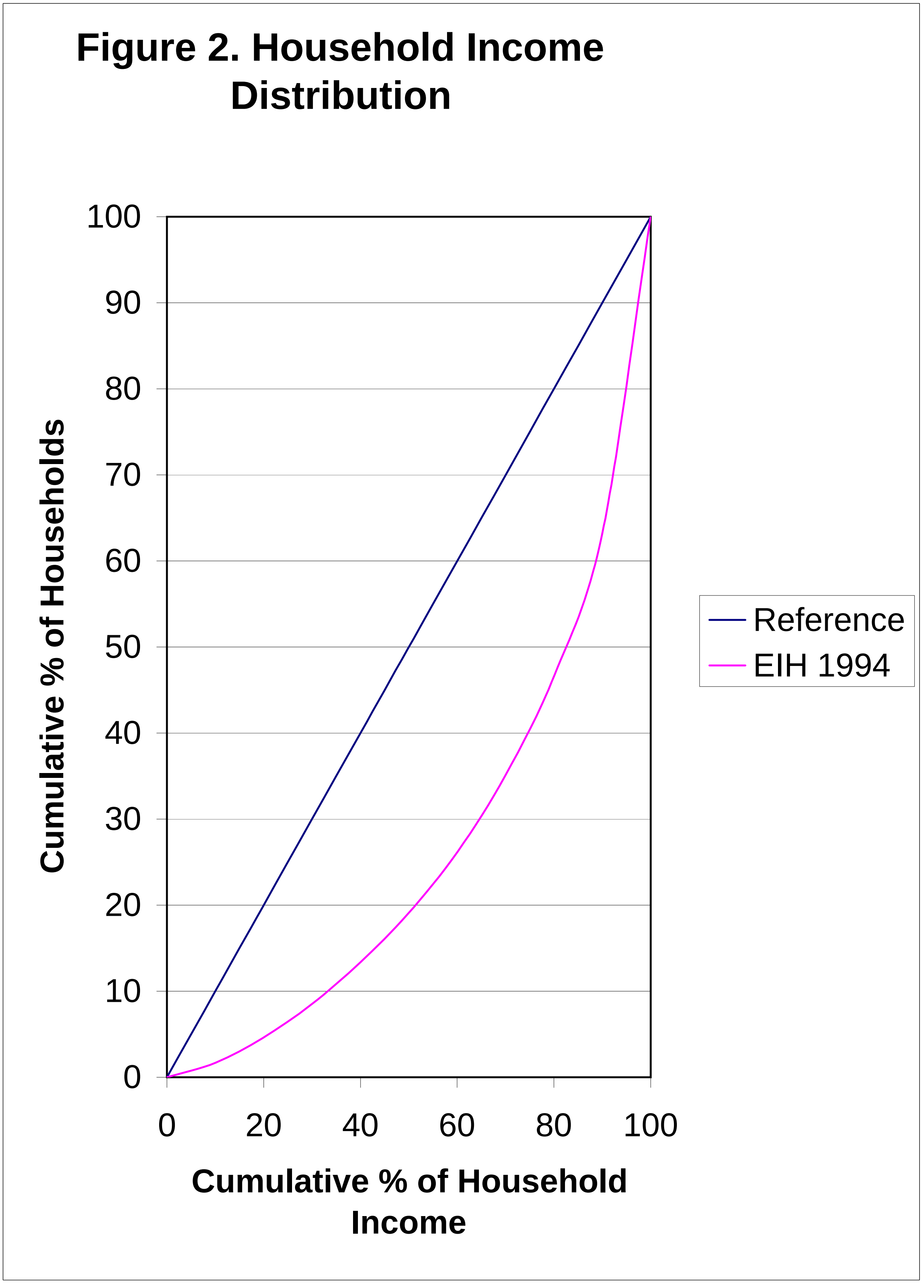


Figure 2. Household Income Distribution
100
90
80
70
60
50
40
30
20
10
0
Cumulative % of Households
0
20
40
60
80
100
Cumulative % of Household Income
Reference
EIH 1994

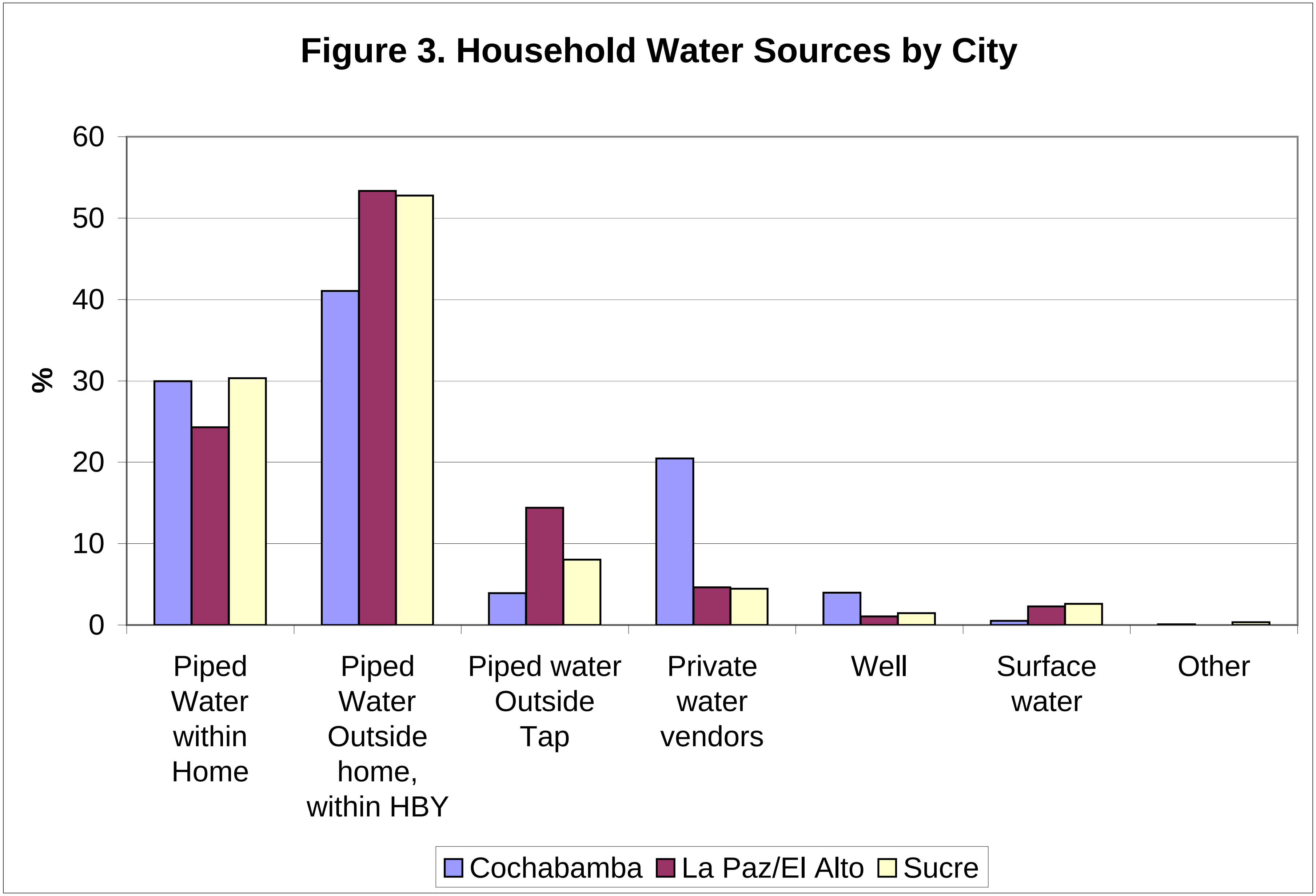
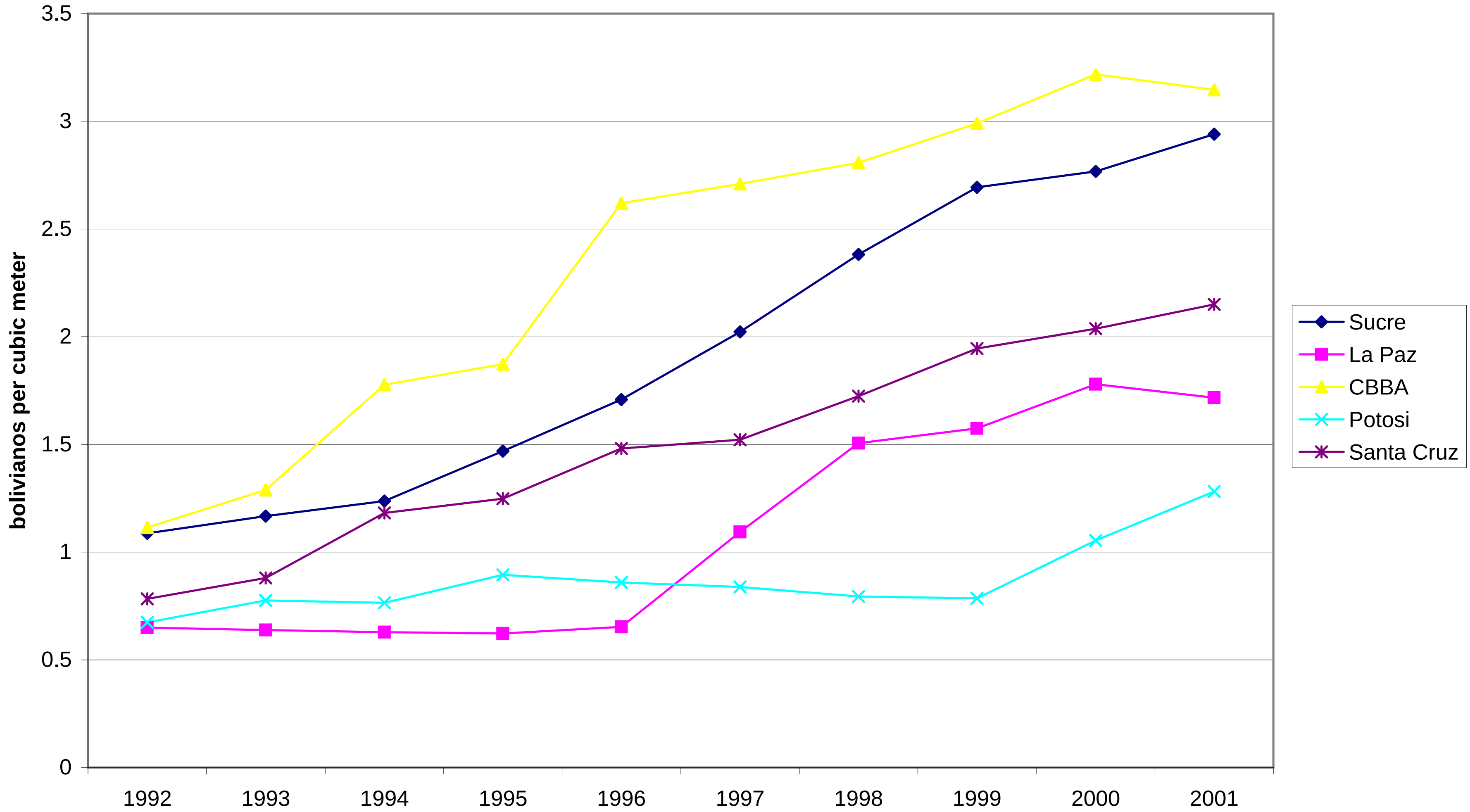


Figure 3. Household Water Sources by City
%
60
50
40
30
20
10
0
Piped Water within Home
Piped Water Outside home, within HBY
Piped water Outside Tap
Private water vendors
Well
Surface water
Other
Cochabamba
La Paz/El Alto
Sucre

Figure 4. Average Residential Water Prices



Source: Author's Calculations from Expenditure and Quantity Data from Bolivian National Institute of Statistics (INE)