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How natural gas tariff increases can influence poverty: Results, measurement constraints and bias

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ABSTRACT

Energy tariff increases are generally essential to address environmental and fiscal concerns but they can also push households into poverty. This paper estimates the expected poverty and distributional effects of a significant natural gas tariff reform in the context of Armenia that increased the country's residential tariff by about 40%. It is the first paper in the literature on energy tariff reforms to *simultaneously* try and control for substitution between all major energy sources (not just some), to take into account the seasonality of consumption over the *full* annual cycle, and to apply different methods to assess changes in household consumption on natural gas and shifts in natural gas between main and supplementary heating sources. Existing papers thus generally overestimate the potential effects of energy price increases on household welfare. The results here – which face, like any statistical study, a set of important methodological constraints – suggest nonetheless that this significant tariff increase led to an estimated 8% of households shifting away from gas, mainly towards wood, as their heating source. It consequently resulted in an estimated 2.8% of households falling below the national poverty line, while likely also influencing non-monetary human welfare that cannot be well captured econometrically. Finally, methodological assumptions and limitations in assessing these relationships, as well as potential policy implications are outlined.

1. Introduction

Governments regularly face the challenge of increasing energy prices. Many important reasons for raising tariffs exist including to ensure that they cover the costs of generation and distribution, to adapt to increases in global energy prices, to internalise environmental costs into energy tariffs and to mobilise sufficient resources to invest in more efficient generation capacity. Over time, inflation can present another reason for increasing energy tariffs in order to reflect real prices, while a rise in gas prices can in turn increase inflation (see also World Bank, 2013). Reducing energy subsidies is also crucial to ensure inequality is not exacerbated, as such subsidies are often highly regressive and thus benefits are disproportionately captured by richer households. But fuel subsidies – while often leading to large public sector deficit – are commonly justified on the grounds that they help the poor. For all households, low or subsidised energy costs can create fewer incentives to save or invest in energy efficiency and provide perverse incentives to overconsume energy, thereby increasing excessive consumption, pollution and depletion of natural resources. Increases in energy tariffs are therefore important to tackle environmental and fiscal challenges and to improve quality and reliability of energy service delivery, on one hand. On the other, it is important to also consider their potential adverse effects on households in terms of energy affordability, especially among the poor. Reducing energy subsidies, however, frees up public resources that can be used much more efficiently and at times are in part redirected to target the poor.

Energy price reform is thus a general issue that constantly confronts all governments across the world. This paper assesses the potential poverty and distribution effects of a significant energy tariff increase within the context of Armenia while the methodological constraints and some of the policy implications outlined here can be relevant for other country studies. For reasons outlined above and especially

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sparked by a Russian gas price hike, the Government of Armenia raised the country's residential price for natural gas by 39.9% (in real terms) on April 1 2010, increasing the retail price from AMD 96 to 132 per cubic meter. In light of this significant gas tariff reform, this paper estimates the results for a partial equilibrium analysis of the reform's potential effects on household welfare; this common method is used as the nationwide reform affected *everyone* so that no randomised controlled trial (in which some would receive the tariff increase while others do not) can be conducted to assess the reform.[1] Yet any econometric study of the potential impact of government reforms encounters – as later outlined – a large number of important methodological limitations, particularly when analysing nationwide reforms as we cannot create a possible counterfactual. It is nonetheless important from a poverty and policy perspective to try and understand the potential welfare and distributional effects of such large price increases borne by households which can be valuable information for policy planners and government officials to better understand the estimated impact of such common reforms. A number of studies across the world indeed show that poor households are more prone to experience economic distress due to energy tariff increases – from Argentina (Cont et al., 2011) and Spain (Hanemann et al., 2013), to Moldova (Baclajanschi et al., 2006), the Ukraine (Mitra and Atoyan, 2012) and other European and Central Asian countries (World Bank, 2007). Gas tariff increases can also have non-monetary, human welfare effects on people through the physiological burden of being cold. In the context of Armenia, the average altitude is 1850 m and temperatures in winter generally range between −10 and −5 °C (14 and 23 °F) (Weather Base, 2013). Gas consumption can thus be viewed as a basic necessity of life in countries with colder winters. But the influences of tariff increases on physical and mental wellbeing cannot be well quantified and thus captured in statistical models, so they are largely ignored in the literature. It is also important to note that gas is the most common household heating source in Armenia – like in many other countries – and is often used as fuel for cooking, heating water and washing clothes (see also Vásquez et al., 2011; Dagher, 2012).

In trying to estimate potential welfare effects of gas tariff increases in the context of Armenia, this paper has three main contributions to the existing literature.[2] It is the first to *simultaneously* try and control for substitution between all (not just some) major energy sources, to take into consideration the seasonality of consumption over the *full* annual cycle, and to apply different measurement methods to assess gas consumption and use of gas as the main heating source. Not taking these issues into account, as this paper shows, has contributed to significantly biased and overestimated results in the energy consumption and subsidy reform literature – for surveys of the literature on estimates of energy demand, see for example Bohi (1981), Al-Sahlawi (1989), Dahl (1993) and Ferrer-i-Carbonell et al. (2002).[3]

First, some papers do not consider substitution between energy sources and assume that households do not alter their gas consumption patterns due to higher prices — i.e. that the elasticity of gas demand to tariff increases is zero (see e.g. Ersado, 2012; Mitra and Atoyan, 2012). This assumption (as expected) does not hold as this paper illustrates. Many other papers control for substitution between gas and electricity and some make important contributions to measuring price elasticities across wealth quintiles. But they do not consider other energy substitutes including wood, liquid fuel or LPG simultaneously, meaning that they too overestimate the potential effects of energy tariff increases — for example, the studies by Baker and Blundell (1991) in the UK, Zhang (2011) in Turkey and Vásquez et al. (2011) in the US.[4] The results here illustrate that in estimating the potential effects of this significant gas price reform in Armenia while not controlling for substitution between *all* the energy sources of gas, electricity, LPG, wood and liquid fuel overestimates the welfare loss in total consumption for households in the bottom quintile by an estimated 36%. Any analysis of energy demand thus needs to explicitly deal with the various forms of substitution and tradeoffs that households make in combining multiple energy sources and shifting between them.

Second, energy consumption can vary immensely across different seasons over a full year, with gas consumption in Armenia about three times higher during the winter months relative to the summer months. Seasonality is however not explicitly taken into consideration in most papers as they do not precisely compare a full 12 month period before a price reform with a full 12 month period after a price reform to capture the entire seasonal cycle over the year — as this paper does. But they instead use different numbers of months not over a full yearly cycle before and after a price increase, thus making the poor, imbalanced comparison for example of half of a winter season (when gas consumption is higher) with a full summer season (when gas consumption is lower) or the like (see e.g. studies by Leth-Petersen (2002) in Denmark, Baclajanschi et al. (2006) in Moldova, Zhang (2011) in Turkey or Hanemann et al. (2013) in Spain). Third, this paper applies different methods to assess potential welfare effects of gas tariff increases, analysing (i) changes in household consumption on gas and (ii) shifts in gas as households' main and supplementary heating source. Such differential analysis also helps gain a richer understanding about the degree of substitution between household energy sources as no single method – although it is the standard approach among papers in the literature – can fully capture the complexities of energy substitution. Finally, this analysis here employs data before and after this significant reform and can thus better capture potential effects of tariff increases than papers that simulate the expected effects of energy reforms using data prior to a reform, which requires many important assumptions including imputed aggregate income growth and estimated demand elasticities.

The paper here is organised as follows. Section 2 describes the data sources used for the analysis. Section 3 provides a brief overview of the country context in Armenia and presents the descriptive results. Section 4 describes the empirical methods, outlines their methodological limitations and presents the regression results, assessing the potential poverty and distributional effects of this significant gas tariff increase including its potential effects on substitution between heating sources.[5] Section 5 concludes, it outlines some general methodological constraints facing the study of energy reforms, and it discusses potential policy responses.

2. Data sources

This paper applies data from the Integrated Living Conditions Surveys (ILCS) in Armenia. These household surveys are conducted by the country's National Statistical Service and are the principal source

[1] The term ‘reform’ is used throughout the paper to reflect tariff increases, although some government officials may not perceive significant price increases as a reform. In addition, the use of the term ‘gas’ throughout this paper refers to natural gas.

[2] Welfare, or welfare quintile, is defined here based on total household per capita consumption.

[3] It is important to note that the surveys of existing analyses show no agreement on the magnitude of demand elasticities, while taking into account that the majority of existing analyses have focused largely on electricity and thus less attention given to natural gas (Dagher, 2012).

[4] For the earliest survey on energy substitutability, see Bohi (1981); for a later survey, see Dahl (1993).

[5] This paper focuses thereby on estimating changes in aggregate demand and in household consumption among different wealth groups. It is beyond the scope of this analysis to assess other effects of energy tariff increases, which can affect reductions in fiscal deficits (IMF, 2013), improvements in the efficiency and effectiveness of the energy sector, reallocate capital and labour towards more energy efficient consumption and sectors (Kilian, 2008) and, among others, enhance environmental sustainability (World Bank, 2013).

of data collected on household expenditure, consumption and income. The survey rounds for 2009, 2010 and 2011 are used for much of the analysis. Each of these surveys collects data from 7872 households annually and is carried out throughout the entire year, with exactly 656 different households surveyed each single month.

The surveys' sampling frame is based on the 2001 Population Census and divided into 48 strata including 12 communities of Yerevan City. All provinces (*marzes*) and Yerevan, as well as urban and rural communities are included in the sample reflecting their respective shares of the total population. Communities in all provinces are grouped into large towns, small towns, and villages. Among the 656 households surveyed each month, 368 are in urban communities and 288 in rural communities. These cross-sectional surveys are representative at the national and provincial levels, as well as for each quarter of the year.

A particularly interesting feature of these surveys is the inclusion of a diary given to and completed directly by household heads. This self-administered questionnaire is used to record daily all current expenditures, consumption and income made by the household during the month. The records in the diary are then collected and verified by the interviewer at the end of the month. Relative to the standard approach of the interviewer asking respective questions in the questionnaire, the main advantage of the diary method is that potential recall bias is minimised, as for example current expenditures are directly recorded as opposed to asking respondents to recall the amount of past expenditures (for more information on the sample design, questionnaire and diary, see ILCS, 2011).

The ILCS household survey data are then combined with data on actual gas tariffs for residential customers. Information on gas prices in Armenia is derived from the Energy Regulators Regional Association (ERRA) database which collects data on gas tariffs from independent energy regulatory bodies, predominately across countries in Central Europe and Eurasia. At the same time, it is important to note that quantitative data alone (or any single data source alone) has its limitations, so several insights using qualitative evidence are also outlined.

3. Background, and descriptive results

3.1. Background and country context

The significant gas tariff increase assessed here was adopted in Armenia — a country that has high levels of poverty with about one third of the population living below the national poverty line in 2011 (35%), even though GDP per capita (a crude measure of economic wellbeing) reached US$3033 in the same year (WDI data). The country has no gas reserves and depends heavily on Russia for natural gas imports which account for about 80% of the country's energy imports and 60% of its energy supply (Ersado, 2012). The country's high dependence on energy imports makes it susceptible to foreign energy price shocks, in particular those from Russia. In addition, average gas tariffs in the country reflect about 40% of cost recovery (World Bank, 2013) which highlights the strong demand for the government to adopt policies to reach cost recovery.

Armenia appears to be among the countries with the least diversified energy portfolio in Eastern Europe and Central Asia, with reported energy consumption in the country being highly concentrated in gas, electricity and wood – which can increase vulnerability to shocks – while in other countries in the region coal, LPG, solid and other fuels account for significant shares of energy consumption (ibid.). At the same time however, cross-country comparisons should be read with caution as gas consumption patterns are shaped by multiple factors that are idiosyncratic to individual countries, including climate conditions, the level of gas subsidies and overall levels of development.[6]

[6] For an overview of how Armenia performs on key indicators of gas access, use and expenditure relative to other countries across Europe and Central Asia, see World Bank (2013).

It is also worth noting that gas and electricity supply in the country are strongly interconnected, as one quarter of electricity is generated by natural gas. In addition, it is important to mention that reforms in the electricity sector – especially increases in electricity tariffs – over the period 1995–1999 contributed to reducing the country's fiscal deficit from 16.5 to 6.3% of GDP between 1994 and 2000 (IMF, 2013).[7]

3.2. Descriptive results

Tables A1–A3 in the Appendix provide summary statistics of the variables applied in the regression analyses. This data shows that natural gas is a critical energy source for households in Armenia and 78.3% of households report gas consumption in 2011. Among the remaining 21.7% of households not reporting gas consumption, 92.9% of these households report that natural gas was not the main heating source used and 95.8% of these households report positive electricity consumption. Thus, non-response of gas consumption does not appear to be a major concern, as households are instead using alternative energy sources.[8] In addition, a methodological issue of using household survey data for statistical analysis is that we only have observations for households that choose to report. In the ILCS Armenia survey, 80.3% of households have access to gas and 78.3% of households report gas consumption, so that therefore 2% of households either choose not to use gas (e.g. due to the use of an alternative energy source or poor quality or reliability of services), they do not pay their gas bills, or choose not to report their gas consumption. Though not a critical concern in Armenia, sample selection can present an important issue in other countries. In Turkey, for example, households have near universal access to electricity but 27.7% of these households do not report any expenditure (Zhang, 2011).

Household consumption on gas varies widely across the country and population groups. For example, 62.3% of rural households and 86.4% of urban households report gas consumption, with two thirds of Armenians (66%) living in urban areas. Household consumption on gas as a share of total household consumption increased from 4.5 to 4.9% between 2010 and 2011, while variation in gas consumption as a share of total household consumption is limited across wealth quintiles and location. However, in the Eastern Europe and Central Asia region as a whole the share is only 1.6% of household spending.

Households in Eastern Europe and Central Asia have some of the highest energy demands for heating due to longer winters relative to households in other regions of the world (World Bank, 2013). Households' monthly gas consumption in the country varies widely over the annual cycle and consistently follows monthly changes in temperatures, with gas consumption about three times higher during peak winter months compared to peak summer months (Fig. 1). Households in the richest quintile are moreover much more likely to increase their gas consumption during winter months, while their consumption levels are similar to those of the bottom quintile during summer months. This suggests that household demand for gas depends on factors other than differences in prices and levels of total household consumption — in particular on seasonality. A US study on interstate differences in demand for natural gas shows that price elasticities vary significantly between geographic areas with very different temperatures and durations during winter, varying from −0.29 for Alaska to −2.24 for Florida (Hsing, 1992).

[7] For a study in the electricity sector on the potential effects of changes in tariff rates on households in Armenia, see Kaiser (2000).

[8] At the same time, it is important to note that ILCS identifies replacement households for those refusing to fill out the questionnaire, accounting, for example, for 7.8% of all visited households for the 2009 survey collection. This may possibly provide some upward bias in energy consumption patterns, as non-responding households are often more likely to be more marginalised.

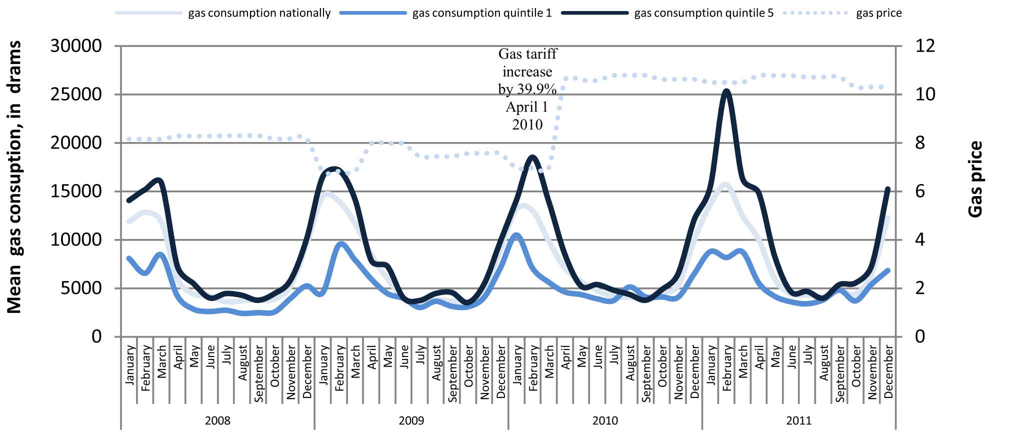

Fig. 1. Trends in mean household gas consumption and gas prices in Armenia.
Source: Calculations based on data from ILCS for consumption and on Erra data for prices. Note: Values have been adjusted for inflation.

As the most important source of household heating in Armenia, the share of households using gas as their main source declined from 56 to 48% between 2010 and 2011, and their reliance on wood increased correspondingly by 6% (Fig. 2). In rural areas, the shift towards wood was larger, with a 13.3% increase in the share of households using wood as their main heating source. This shift in rural areas corresponded to a decrease in natural gas usage as the main heating source, falling from 33% in 2010 to 19% in 2011. Moreover, a survey conducted after the 2010 gas price increase covering 2000 households of multi-apartment blocks illustrates that the use of gas for heating declined in 2010 – while the use of firewood for furnaces increased – as a result of the increased gas price (EDRC, 2011). After gas, the second and third most important main heating sources in Armenia in 2011 are wood (at 31%) and electricity (at 13%). There is however large variation across consumption quintiles and location, with poorer and especially rural households much more likely to rely on wood (while less likely to rely on gas) than wealthier and urban households. For example, while 63.4% of urban households use gas as their main heating source at home, 65.6% of rural households use wood as their main heating source.

In analysing the degree of substitution between energy sources, Fig. 2 illustrates that substitution is more strongly concentrated in rural areas, where nearly half of all households use a supplementary heating source in their home. Households likely pursue strategies of substitute energy sources including supplementary heating sources due to issues of access, costs and quality of services such as power outages.

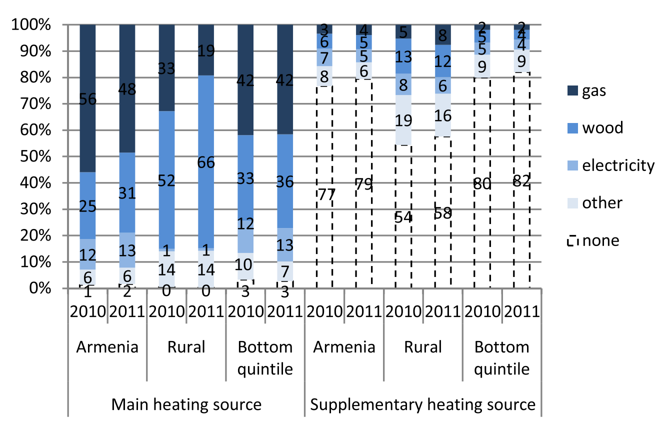

Fig. 2. Main and supplementary heating source by share of households, across subgroups in 2010 and 2011.
Source: Calculations based on data from ILCS. Note: *Other* heating sources include central heating, liquefied gas, oil and diesel, and any other source.

While about one third of total households in Armenia (and two thirds of rural households) use wood as their main heating source at home, less than 1% of households report any consumption expenditure on wood (Table A2), suggesting that nearly all wood consumed by households is collected and not purchased. There is thus important measurement error in analysing household consumption expenditure on wood relative to actual wood consumption — for further information on descriptive data, see Tables A1–A3 in the Appendix.

4. Model and regression results

4.1. Model and its limitations

Any study that attempts to assess reforms that are implemented nationwide faces particularly difficult methodological constraints as such reforms affect everyone and thus do not allow for researchers to build a possible counterfactual. To estimate potential welfare effects of tariff increases, the common approach among economists is to estimate demand functions of gas consumption relative to gas prices. Econometric analyses, which model household gas consumption as a function of household income, gas tariffs and household traits, often assume homogenous price elasticities. This is particularly the case for aggregate analyses over time or across countries. Swan and Ugursal (2009) provide a review of modelling techniques used to assess end-use energy consumption in the residential sector. In contrast to the standard econometric approach, some studies have estimated differentiated welfare losses associated with energy price increases by estimating a demand model across different wealth groups such as Nesbakken (1999) in Norway and Zhang (2011) in Turkey. These studies, while helping to make contributions to understanding differentiated welfare effects of energy tariff reforms, do not simultaneously consider substitution between all major energy sources and the seasonality of energy consumption, and they do not apply different measures of energy use and consumption.

A partial equilibrium analysis, which accounts for the linkages between energy sources, is conducted here of the potential welfare effects of the 2010 gas tariff reform that increased the residential gas price by 39.9% in Armenia. The short-run demand model here estimates the wealth-based heterogeneity in price elasticities by incorporating interaction terms of gas price with consumption quintiles — i.e. the coefficient of the log of price measures the price elasticity of gas demand. In estimating price elasticities for households in each wealth quintile, the model provides results of the differentiated distribution of demand elasticities across the population. Such disaggregated analysis of price responsiveness of demand for different households with different wealth levels is relevant for policy, in comparison to (as mentioned) the large literature of aggregate studies that assume that households all respond the same to demand factors such as energy prices, different seasons of the year and so forth.

24 months of household survey data is used that includes the exact 12 month period prior to and after the April 1 2010 gas tariff reform in Armenia, i.e. data from April 2009 to March 2011. By incorporating the full 12 month period before and after the reform, the model aims to capture seasonality of gas demand — shown to be critical in Fig. 1 above. This, together with the inclusion of variables for differences in urban/rural location and across provinces, helps address variations in climate conditions (see also Uri, 1983; Hanemann et al., 2013).[9] The price of gas is treated as exogenous as it is sold at a flat rate over this period, i.e. the marginal price is the same for different levels of gas consumption and for all consumers independent of location or wealth levels. (Instead, under multistep block pricing – which, internationally, is the most common way of implementing tariff subsidies – this would be a methodological concern and give rise to specification difficulties, as the price of gas is then a function of the quantity of gas consumed.)

The expected welfare effects of this gas tariff reform are estimated using ordinary least squares (OLS) regressions, which is the most common method used in the literature (see for example: Zhang, 2011; Mitra and Atoyan, 2012). The dependent variable is the log of household gas consumption. Independent variables include an interaction term of the log of gas price with consumption quintiles, the log of total per capita consumption, the log of consumption on other energy sources to capture substitution, dwelling characteristics, ownership of household assets, household demographic traits and, among other variables, geographic location (see Table 1). Total per capita consumption, which is calculated for the analysis while excluding gas consumption, is used rather than income, as income is often underreported in household surveys. It is possible to estimate expected substitution effects here as the model only includes households with positive gas consumption (reflecting 71.1% of all 15,744 households surveyed over this two year period) while controlling for simultaneous consumption on electricity, LPG, wood, and liquid fuel. That is, households without any gas consumption have been omitted from the sample for this analysis. Controlling for location is important as the descriptive data shows that the degree of household dependence on gas varies strongly by location. In addition, a number of studies also stress the need for sub-national disaggregation when estimating elasticities of residential energy demand — e.g. Garcia-Cerrutti (2000) using data across California, Hanemann et al. (2013) using data in Spain, Baker and Blundell (1991) using data in the UK, and Bernstein and Griffin (2006), Uri (1983) and Hsing (1992) using data across the US.

Because aggregation often hides potentially important effects that influence some subgroups but not others, other model specifications are also calculated for the potential effects on sub-samples of the population. These include urban households, rural households, recipients of the country's main social safety net (the Family Benefit programme),[10] and households below the national poverty line, analysis of which helps increase the policy relevance of the results.

From a methodological perspective, it is important to note that demand for energy is contingent on a number of factors that cannot all be known and measured and thus fully captured in such statistical models. These unobservable factors can include improvements in the efficiency of service delivery in the energy sector over the analysed time period, information about household decisions on consuming less energy to reduce potential negative environmental effects or to make greater investments in say education or health, changing social norms about different types of energy consumption and, among many other factors, particular variations in climate conditions not available at the same level of aggregation as the households surveyed for the analysis. Such omitted variables can reduce the predictive power of the estimated coefficients as they can be correlated with independent variables, so that there would be a correlation between the error term and independent variables. The analysis here, while acknowledging these important methodological limitations, focuses on exploring those quantifiable factors that can help influence energy demand found in ILCS survey data. It is important to stress that the estimated results do not reflect definitive causal effects, that they do not go beyond statistical correlations.

4.2. Potential effects of the 2010 gas tariff increase in Armenia on household gas consumption

This gas price increase is estimated to have had a strong, negative and significant effect on household gas consumption. The main result in Table 1 suggests that the estimated effect of a 1% increase in gas price led to a 0.13% reduction in households' monthly gas consumption (column 6), while controlling for those factors captured in the model.[11] Thus, the gas tariff increase by 39.9% in 2010 reduced total household gas consumption on average by an estimated 5.3% which is relevant policy information for government officials in Armenia. At the same time, it is important to note that there are large variations between studies in their reported results about the potential effects of changes in prices on changes in consumption across countries and years (for an overview: Bohi, 1981; Dahl, 1993; Ferrer-i-Carbonell et al., 2002; Dagher, 2012). This means that it is unlikely for a gas price increase of about 40% to result in a 5% reduction in gas consumption in a different time period in Armenia or in another country. In Spain, for example, a study conducted using household data by Hanemann et al. (2013) estimates that a 10% increase in the price for natural gas would lead to a 3.2% reduction in its consumption. In the Ukraine, a 10% gas tariff increase decreased gas consumption by an estimated 2.6–2.8% (Mitra and Atoyan, 2012). In the Netherlands, an energy tax was introduced that increased the price for gas by 3–10% over the period 1996–1999 which led to an average estimated reduction of 4.4% per year in household gas consumption (Berkhout et al., 2004).

The results here show that household gas demand in Armenia responded differently to the price change across different wealth groups, with a 1% increase in gas price having led to an estimated 0.15% reduction in monthly gas consumption for households in the poorest two quintiles and an estimated 0.105% reduction for households in the richest quintile (column 2). Richer households were thus less likely to adjust levels of gas consumption due to the gas price increase. Not controlling for all other major sources of energy consumption can lead to biased results as column 1 results show and have been included only for comparative purposes. With two thirds of urban households using gas to heat their homes compared to about one quarter of rural households, the higher gas price had the largest estimated effects on reduced gas consumption among urban, poor households (column 3). This provides some evidence against the theoretical assumption that poorer households are less likely to adjust consumption patterns as they are more likely to already consume gas at or near a minimal level with less space to adjust to higher prices than richer households. Also, poor households in urban areas have less access to wood as a substitute. In running the regressions for other sub-samples, the respective reduction in gas consumption was an estimated −0.19% for the average

[9] The mean temperature in Armenia was nearly identical over the 12 month period captured before the reform (at an average of 8.8 °C between April 2009 and March 2010) and after the reform (at an average of 9.2 °C between April 2010 and March 2011) (Climateportal, 2016).

[10] The programme provides a monthly cash benefit targeted to needy families, with about 60% of programme recipients falling into the poorest quintile. The programme's benefits received by households can be viewed, while not its primary objective, as an indirect subsidy for energy costs.

[11] Estimated effects are identical if the model is run including the log of gas price as an independent variable while omitting the interaction term for quintile 1, for example. Results are consistent with a few studies in the literature, with short-run price elasticities for natural gas estimated at −0.12 in a study by Bernstein and Griffin (2006) and at −0.20 in a study by Bohi and Zimmermann (1984).

Table 1
Estimated effects of the 2010 gas tariff increase on household gas consumption in Armenia.

Dependent variable: household gas consumption, log	(1) W/out other energy consumptions (full sample)		(2) W/ other energy consumptions (full sample)		(3) Urban		(4) Rural		(5) W/ provinces (full sample)		(6) Homogenous price elasticity: Full sample		(7) Homogenous price elasticity: Family benefit recipients		(8) Homogenous price elasticity: Households below poverty line	
Independent variables	Coef.	t–stat	Coef.	t–stat	Coef.	t–stat	Coef.	t–stat	Coef.	t–stat	Coef.	t–stat	Coef.	t–stat	Coef.	t–stat
Total per capita consumption																
Log of gas price * Quintile 1	−0.139**	−2.4	−0.147***	−2.6	−0.253***	−3.7	0.123	1.3	−0.153***	−2.7						
Log of gas price * Quintile 2	−0.140**	−2.5	−0.151***	−2.7	−0.252***	−3.7	0.091	1.0	−0.153***	−2.8						
Log of gas price * Quintile 3	−0.113**	−2.0	−0.127**	−2.3	−0.217***	−3.2	0.082	0.9	−0.124**	−2.3	−0.134**	−2.5	−0.233	−1.5	−0.186*	−1.9
Log of gas price * Quintile 4	−0.103*	−1.8	−0.119**	−2.1	−0.215***	−3.1	0.097	1.0	−0.114**	−2.0						
Log of gas price * Quintile 5	−0.087	−1.5	−0.105*	−1.8	−0.200***	−2.8	0.099	1.0	−0.095	−1.6						
Log of total per capita consumption	0.348***	7.5	0.295***	6.4	0.273***	5.4	0.424***	3.7	0.305***	6.6	0.352***	15.1	0.259***	3.3	0.422***	6.3
Log of electricity consumption			0.189***	7.6	0.189***	6.0	0.194***	4.7	0.203***	7.2	0.190***	7.6	0.240***	3.6	0.188***	4.9
Log of LPG consumption			−0.067***	−2.7	−0.065**	−2.0	−0.084**	−2.2	−0.063**	−2.5	−0.066***	−2.6	0.156***	4.2	−0.025	−0.5
Log of wood consumption			−0.034**	−2.4	−0.033	−1.2	−0.042***	−3.2	−0.034**	−2.4	−0.035**	−2.5	−0.021	−1.1	0.015***	3.4
Log of liquid fuel consumption			0.028*	1.8	0.044*	1.9	0.001	0.1	0.026*	1.7	0.030*	1.9	0.051***	3.3		
Urban	−0.031	−1.3	−0.059**	−2.6					−0.033	−1.5	−0.061***	−2.6	−0.063	−1.0	−0.033	−0.9
Households with 1 to 3 members (ref. 6+)	−0.651***	−23.8	−0.528***	−16.3	−0.538***	−13.4	−0.486***	−8.9	−0.521***	−15.8	−0.523***	−16.2	−0.621***	−7.1	−0.697***	−12.8
Households with 4 to 5 members	−0.209***	−9.0	−0.170***	−7.3	−0.179***	−6.1	−0.144***	−3.8	−0.169***	−7.3	−0.168***	−7.2	−0.152**	−2.5	−0.178***	−4.8
Floor area, m^2	0.338***	15.0	0.315***	14.1	0.346***	13.2	0.223***	5.2	0.312***	13.8	0.316***	14.1	0.226***	3.3	0.122***	3.0
Gas is main heating source	0.426***	20.6	0.431***	21.0	0.448***	16.9	0.389***	12.5	0.427***	20.2	0.432***	21.1	0.388***	7.0	0.234***	6.9
Centralized hot running water	0.099***	5.0	0.068***	3.5	0.050**	2.2	0.131***	3.5	0.090***	4.5	0.068***	3.5	0.069	1.2	0.054	1.6
Yerevan (ref. Vayots Dzor)									−0.238***	−5.2						
Aragatsotn									−0.440***	−7.5						
Ararat									−0.172***	−3.3						
Armavir									−0.182***	−3.7						
Gegharkunik									−0.068	−1.5						
Lori									−0.077	−1.6						
Kotayk									0.053	1.1						
Shirak									−0.008	−0.2						
Sjunik									−0.097*	−1.9						
Tavush									−0.270***	−5.3						
Constant	2.876***	4.8	2.174***	3.5	2.470***	3.6	0.313	0.2	2.048***	3.3	1.460***	4.6	2.838**	2.6	1.440	1.6
Observations	11,143		11,143		7,256		3,887		11,143		11,143		1,182		3,007	
Adjusted R–squared	0.268		0.291		0.280		0.340		0.306		0.291		0.294		0.274	

Source: Calculations based on data from ILCS. Note: *** p<0.01, ** p<0.05, * p<0.1 Robust standard errors are calculated. All consumption expenditures are in local currency, Drams.

household below the national poverty line (column 8). These poor households reduced their gas consumption more than the average household due to the tariff increase, suggesting the need for greater policy attention to the poor.

As expected, gas consumption not only reduces in response to price increases but it also increases as total household consumption rises. Estimations of income elasticity show that a 1% increase in total per capita consumption led to an estimated 0.35% increase in gas consumption.[12] In a UK study, for example, Baker and Blundell (1991) also estimate a positive relationship here while Bohi (1981) in contrast claims that household income is not always an important variable in explaining household demand for natural gas.

Estimated results in column 2 are statistically significant in showing that at the national level households mainly substitute between gas and two other energy sources: liquefied petroleum gas (propane) and wood. That is, households with higher LPG or wood consumption on average decrease gas consumption correspondingly. On the other hand, households are more likely to combine gas and electricity, and gas and liquid fuel. Descriptive data shows that 71.1% of households consume gas and 98.8% consume electricity, suggesting near to universal electricity consumption in the country. It is thus not unsurprising that greater electricity consumption is significantly correlated with simultaneously increased gas consumption. A 1% increase in electricity consumption corresponds to an estimated 0.19% increase in gas consumption. It is worth noting that an increase in the price of gas has the potential to affect not only the cost of a household's consumption basket but also the price of other energy sources including electricity, since as mentioned one fourth of the country's electricity supply is generated with natural gas; though, the electricity tariff remained the same over this period.

Table 1 also identifies potential household-level influencers of gas consumption. A larger number of household members is estimated to be, as expected, a consistent and strong influencer of higher gas consumption — for similar results see for example Hanemann et al. (2013). A 10% increase in the floor area of a home increases gas usage by an estimated 3.2%. Other studies also estimate a similar relationship between size of the house and increased gas consumption — for example, Leth-Petersen (2002) using data in Denmark and Mitra and Atoyan (2012) using data in the Ukraine. Household gas consumption is estimated to also be positively and significantly influenced by having centralised hot running water and especially by gas being the main heating source used.

4.2.1. Robustness checks

As there are only minimal gas price variations over the analysed 24 month period apart from the 39.9% increase in April 2010, estimated results are very similar when testing the model with gas prices that are averaged over the 12 month period before and the 12 month period after the reform. In addition, the model is tested with interaction terms of consumption quintiles with a reform dummy variable instead of the gas price — with 0 reflecting the 12 month period prior to the April 2010 reform and 1 reflecting the 12 month period after the reform.

[12] In including total per capita consumption, the model also aims to control for potential effects of the increased gas tariff on changes in consumption levels for food and/or transportation, as costs for some non-gas goods and services may increase in unison with higher gas costs.

Results suggest that the tariff reform led to an estimated 10% decline in household gas consumption for those in the poorest two quintiles and to an estimated 6% decline for those in the fourth quintile, while the effect on households in the richest quintile was not statistically significant, with other parameters remaining very similar.

It is conceivable that some households may have only noticed the tariff increase after they received their gas bill. In order to take potential delayed response to the price change into account, the model is tested with a one-month and a two-month delay (adjusting for the 12 month period before and after the reform). Results show that the coefficients for the other control variables remain very similar, but the estimated size and strength of coefficients for the gas price variable drastically reduce, suggesting that there was little or no lag in responding to the tariff increase. It is thus important to remember that a possible correlational (or 'causal') claim is always a function of when baseline and endline data points happen to be chosen.

As a further robustness check, including month and year fixed effects deplete, as expected, the explanatory value of the gas price, while the coefficients of other parameters are nearly unchanged. Zhang (2011) includes a dummy variable for whether households rent their dwelling to test if unobserved differences related to household ownership may affect energy consuming behaviour, but the estimated effects on gas consumption in Armenia appear very small and not significant. Finally, testing the robustness of the demand estimation using total income instead of total consumption suggests that the parameters remain highly consistent.

4.3. Potential effects of the 2010 gas tariff increase in Armenia on households' selection of main heating source used

Assessing gas tariff increases using household consumption expenditure data alone (or any single method alone) can provide a more incomplete understanding of their potential effects on household welfare. This is mainly because wood is an important substitute for gas and it is used (as mentioned) by 31% of Armenian households as their main heating source but less than 1% report any consumption expenditure on wood (as it is collected). Also, energy consumption expenditure data alone does not capture issues such as non-payment of energy used. Thus, in contrast to the gas consumption model above, probit regressions are conducted here that include all households in the survey, that use households' main heating source used as the dependent variable and that can thus better capture the use of wood. These probit regressions help provide insight into the extent to which households shifted away from the use of gas as a heating source due to the 2010 tariff increase. By applying 24 months of data over 2010 and 2011, they capture the reform's potential effects on substitution between main heating sources and between main and supplementary heating sources used by households.[13]

To estimate the potential distributional effects of the reform on households across wealth quintiles, interaction terms are created between the pre- and post-reform periods (0 or 1) and household quintile levels (0 or 1).[14] Likewise, interaction terms are also included between the pre- and post-reform periods and households' supplementary heating source (0 or 1). For more information on variables and summary statistics, see Table A3 in the Appendix.

The estimated marginal effects of the probit regressions are presented in Table 2. The main result is that as a consequence of the tariff increase, the estimated likelihood for households to use gas as their main heating source decreased by 8% and consequently increased by 6% for wood, 1% for electricity and 1% for any other source as their main means to heat their home, while controlling for those factors captured in the model. Most substitution effects of the reform seem to thus reflect shifts away from gas towards wood consumption. This may be in part due to wood being an alternative energy source that typically has no direct financial costs. A lack of access to electricity, if used as a heating source, is not a primary explanation for why more households did not shift to electricity (given as mentioned nearly universal access to electricity at 99%). This rapid shift between energy sources identified here is contrary to the standard view in the literature that substitution between sources is technically difficult for households in the short run (see e.g. Ferrer-i-Carbonell et al., 2002). This misconception in the literature is likely because most studies use a single measurement method and do not include data on shifts towards wood as households' main heating source.

Results suggest that the likelihood to shift away from gas as the main heating source was similar across wealth quintiles, with households within quintile 1 an estimated 5.8% less likely to use gas and those within quintile 5 an estimated 8.3% less likely to use gas (see second to last column in Table 2). Beyond shifts in the main heating source, households using gas as their main source were an estimated 13% more likely to use electricity as a supplementary heating source as a result of the price increase. Household substitution between natural gas and electricity is often limited to using space heating, water heating, cooking, and drying and washing clothes (Dagher, 2012). Consumers can thus generally choose between natural gas and electricity for such uses of appliances depending on changes in relative prices and other factors (see also Vásquez et al., 2011). The results here on substitution contrast with those of a study conducted within the US that illustrates weak potential effects of changes in prices in natural gas or electricity on changes in consumption of the other respective energy source, suggesting that in some contexts natural gas and electricity may at times be used largely independent of each other (Garcia-Cerrutti, 2000).

4.4. Potential poverty effects and total welfare losses due to the 2010 gas tariff increase in Armenia

This section examines the potential poverty and total welfare effects – as a share of total household consumption – of this 2010 price increase. The total household welfare losses from the tariff increase are estimated here, likewise, by comparing the initial gas consumption and price with the new gas consumption and price. OLS regressions are conducted that control for the same factors as in the full regression model 1. It is important to reiterate that only households with gas consumption would be directly affected by the tariff increase, with households without any gas consumption omitted from the sample. The estimated results in column 1 within Table 3 (the total household welfare loss in the amount of gas consumption) reflect household changes in actual gas consumption due to the tariff reform, while the estimated results in column 2 (the household welfare loss as a share of total household consumption) reflect the share of total household consumption accounted for by the change in gas consumption (as indicated in column 1 results).

Table 3 suggests that the 39.9% gas tariff increase led to an estimated welfare loss of −1.1% of total household consumption for the average household in the poorest quintile, implying a total welfare loss at the expense of other basic necessities. This means that the partial reduction in gas consumption made by households in light of the price increase (Table 1) did not fully compensate for the overall price increase so that households still increased their total household consumption in light of the price increase (Table 3). The burden falling on households in the poorest quintile is about twice as high compared to those in the second quintile, implying that the total potential welfare effects of gas

[13] Data for 2010 and 2011 are used for the analysis on heating sources, as respondents provided one response for their main and one response for their supplementary heating source over these two years. Respondents in the 2009 and earlier surveys were however given one question and could report multiple heating sources so that it is not possible to compare results for these earlier survey years with the 2010 and 2011 surveys.

[14] A dummy variable for the pre- and post-reform periods is used as opposed to gas prices, as the results are more straightforward and easier to interpret. The results of a model using the log of the gas price show nonetheless that the estimated effects and the remaining parameters remain consistent, since apart from the gas tariff increase there are only minimal variations in the gas price over this period.

Table 2
Estimated marginal effects of the 2010 gas tariff increase on households' selection of main and supplementary heating source in Armenia.

			Main source natural gas		Main source electricity		Main source wood		Main source other		Main source natural gas			
			Estimated effects of reform across quintiles, (reference group, quintile 5)								Including five quintiles		Including reform variable, without five quintiles	
	Independent variables		Coef.	t–stat	Coef.	t–stat	Coef.	t–stat	Coef.	t–stat	Coef.	t–stat	Coef.	t–stat
Effects of the tariff increase	Pre–or post–reform (0 or 1)		–0.082***	–3.0	0.012*	1.7	0.059***	3.2	0.010*	1.7			–0.069***	–3.4
	Pre–or post–reform * Quintile (total per capita consumption)	Quintile 1	0.025	0.7	–0.010	–1.0	0.015	0.4	–0.011	–1.4	–0.058*	–1.9		
		Quintile 2	0.014	0.5	–0.020***	–2.7	0.030	1.2	–0.004	–0.6	–0.069***	–2.7		
		Quintile 3	0.018	0.7	–0.013*	–1.8	0.015	0.7	–0.002	–0.3	–0.065***	–2.7		
		Quintile 4	0.019	0.9	–0.005	–0.7	0.002	0.1	0.001	0.1	–0.064***	–2.7		
		Quintile 5									–0.083***	–3.0		
	Pre–or post–reform * Supplementary heat source	Natural gas			–0.029***	–3.2	0.052	0.8	–0.009	–0.6				
		Electricity	0.127**	2.3			–0.074**	–2.0	–0.019***	–3.0	0.127**	2.3	0.127**	2.3
		Wood	–0.060	–0.9	–0.046***	–8.6			0.027	1.5	–0.060	–0.9	–0.059	–0.9
		Other	0.027	0.4	–0.042***	–5.0	–0.029	–0.6			0.027	0.4	0.029	0.4
Potential influencers of heating source	Log of total per capita consumption		0.140***	6.0	–0.017**	–2.5	–0.089***	–4.5	–0.028***	–3.9	0.140***	6.0	0.129***	10.4
	Supplementary heat source	Natural gas			0.350***	5.1	0.395***	5.5	0.035	1.0				
		Electricity	0.127**	2.5			0.090*	1.8	0.036	1.5	0.127**	2.5	0.128**	2.5
		Wood	0.296***	6.2	0.123**	2.0			0.138***	3.8	0.296***	6.2	0.296***	6.2
		Other	–0.311***	–6.3	–0.015	–0.7	0.620***	14.2			–0.311***	–6.3	–0.312***	–6.3
	Urban		0.472***	43.4	0.080***	16.3	–0.314***	–26.3	–0.070***	–10.7	0.472***	43.4	0.472***	43.4
	Households with 1 to 3 members (ref. 6+)		–0.070***	–4.1	0.043***	5.5	0.011	0.8	–0.000	–0.1	–0.070***	–4.1	–0.070***	–4.1
	Households with 4 to 5 members		0.002	0.1	0.024***	3.4	–0.020	–1.6	–0.004	–1.1	0.002	0.1	0.002	0.2
	Floor area, m^2		0.150***	10.5	–0.055***	–9.9	–0.025**	–2.1	–0.006	–1.6	0.150***	10.5	0.151***	10.5
	Yerevan (ref. Vayots Dzor)		0.162***	6.7	0.041***	3.8	–0.211***	–12.1	–0.018***	–3.3	0.162***	6.7	0.162***	6.7
	Aragatsotn		0.050	1.6	–0.051***	–13.3	–0.063***	–3.0	0.013	1.6	0.050	1.6	0.050	1.6
	Ararat		0.213***	8.6	–0.010	–1.2	–0.058***	–2.8	–0.026***	–9.5	0.213***	8.6	0.213***	8.6
	Armavir		0.344***	17.7	–0.021***	–3.2	–0.083***	–4.5	–0.024***	–7.9	0.344***	17.7	0.344***	17.7
	Gegharkunik		0.082***	2.9	–0.032***	–6.0	0.073***	2.7	–0.011***	–2.6	0.082***	2.9	0.082***	2.9
	Lori		0.173***	7.0	–0.016**	–2.2	0.008	0.4	–0.023***	–7.2	0.173***	7.0	0.173***	7.0
	Kotayk		0.226***	9.7	0.018	1.6	–0.143***	–10.3	0.010	1.4	0.226***	9.7	0.227***	9.7
	Shirak		0.269***	12.2	–0.046***	–11.0	–0.133***	–8.6	0.021**	2.4	0.269***	12.2	0.270***	12.2
	Sjunik		–0.045	–1.5	0.034**	2.4	0.041	1.6	0.003	0.5	–0.045	–1.5	–0.044	–1.5
	Tavush		–0.158***	–5.3	–0.043***	–10.6	0.445***	14.6	–0.030***	–12.9	–0.158***	–5.3	–0.158***	–5.3
	Observations		15,735		15,735		15,735		15,735		15,735		15,735	
	Pseudo R–squared		0.190		0.223		0.356		0.271		0.190		0.189	

Source: Calculations based on data from ILCS. Note: The same note applies as in Table 1. Other heating source includes central heating, liquefied gas, oil and diesel, and 'other'. Moreover, 1.5% of households reported not using any heating source.

price changes are disproportionally borne by the poorest households. This exercise illustrates the importance of controlling for substitution between energy sources, because testing the model without the variables for household consumption on electricity, LPG, wood or liquid fuel suggests that the total welfare loss for households in the bottom quintile would be overestimated at −1.5%. While the welfare losses as a share of total household consumption due to the tariff increase may appear rather limited, it is important to note that they can reflect significant losses in absolute terms for poor households and that Armenian households across wealth quintiles already allocate (as mentioned) on average between 4 and 5% of their household budget to gas.

Another important result here is that the total welfare loss due to the gas price increase resulted in an estimated 2.8% of households falling below the national poverty line. These estimates are in line with some studies in other countries. In Moldova, for example, the expected effect of a 37.5% gas tariff increase was estimated at 2.1% of the household budget of those in the poorest quintile that report gas expenditures (Baclajanschi et al., 2006). In the Ukraine, a study estimated that a 40% gas tariff increase would raise poverty by about 2% in the country (Finkel, 2006).

Table 3
Estimated total household welfare losses due to the 2010 gas tariff increase in Armenia.

Quintile (total per capita consumption)	Total household welfare loss in the amount of gas consumption (in drams)	Household welfare loss as a share of total household consumption
Quintile 1	−1715***	−1.1%
Quintile 2	−1204***	−0.6%
Quintile 3	−414*	−0.15%
Quintile 4	−105	−0.03%
Quintile 5	1831***	0.25%

Source: Calculations based on data from ILCS. Note: The same note applies as in Table 1.

4.5. Other potential non-monetary and environmental implications of the gas tariff increase that cannot be well quantified

Assessing the effects of gas tariff increases on household poverty and welfare always encounters important measurement constraints. Especially subsequent increases in wood consumption have a number of implications on non-monetary human welfare that cannot be easily measured and are thus often neglected in economic research and in policy. One, wood is a less effective energy source in terms of warmth and its use can have non-monetary, human welfare effects through the physiological burden of being cold. A survey conducted after the 2010 gas price increase covering 2000 households of multi-apartment blocks illustrates that 44.5% of households reported cases of illness/sickness as a result of insufficient heating conditions over the course of the 2010–2011 heating season (EDRC, 2011). It also shows that only about 23% of surveyed households were satisfied (either partially or fully) with their heating conditions that use a firewood stove, while about 85% of households were satisfied that use central heating (ibid.). Two, wood is a less efficient energy source in terms of its higher carbon emissions per unit of warmth.[15] Shifting to greater wood consumption can thus have adverse implications for the environment related to deforestation (Melikyan and Ghukassyan, 2011). Without attributing any form

[15] In a conference on the 8th of November 2013 on gas and electricity price increases with counterparts from the Government of Armenia and the World Bank – in which the author participated – government officials raised concerns about the use of wood due to issues related to sustainability and environmental externalities. Furthermore, in relation to the extreme poor, government officials to some degree relativised the effects of increased gas prices by stating that water is more of a fundamental necessity than gas, as one cannot do without water but without gas one can often wear an additional coat or blanket.

of causality at all, the country's limited forest coverage decreased from 12 to 9% of its total land area between 1990 and 2011 (WDI data). Three, wood is commonly collected by children and can influence the amount of time allocated to other activities such as leisure and play, or even schooling. Four, in terms of health and poor air quality, using an open fire at home for cooking and heating can lead to respiratory problems, and can increase the number of accidents related to burns and fires. Five, even among households that resorted to collecting wood as a result of the increased gas price and thus the tariff increase did not directly affect their monetary welfare levels, these households may have experienced increased levels of social stigma associated with collecting and heating with wood as opposed to gas as its modern alternative.

In terms of qualitative evidence, case studies collected across Eastern Europe and Central Asia illustrate that some poor households adopt other energy saving behaviours such as keeping only one room inside the home heated (EDRC, 2011), staying longer hours in warmer places such as at work, going to bed earlier, sleeping with more clothes and, among others, using gas only for tasks like cooking (World Bank, 2013). There is thus a number of unique rationing, smoothing and substituting mechanisms that households can pursue. And these present further constraints to the quantitative analysis of gas demand conducted in such controlled settings that aim to hold constant particular background conditions beyond the reform. Combining quantitative with qualitative results – when evidence is available – can always help better inform policy.

5. Conclusion, methodological constraints and potential policy responses

The objective of this paper has been to estimate the potential welfare and distributional effects of a significant gas price increase of 39.9% in the context of Armenia using two separate measurement methods, controlling simultaneously for substitution between all major energy sources, and taking the seasonality of consumption over the full annual cycle into consideration. This tariff reform seems to have had important monetary and human welfare effects on households. Results suggest that it led an estimated 8% of households to shift away from gas, mainly to wood, as their heating source. It also led to an estimated welfare loss of −1.1% of total household consumption for the average household in the poorest quintile, with welfare losses significantly diminishing for richer quintiles, implying that a uniform increase in the price of gas can be rather regressive. The reform consequently resulted in an estimated 2.8% of households falling below the national poverty line. The results here point to advantages of using different methodologies to analyse energy demand and substitution.

At the same time however, any paper trying to estimate the possible effects of energy tariff increases – or any government reform for that matter – faces a set of demanding methodological assumptions and constraints. It is important to stress here that household gas demand – like any economic phenomenon – evolves over time, with changes in energy use, in the efficiency of gas appliances, in the awareness of environmental externalities, in access to natural gas in rural areas and the like. Such changing factors affect the relationship between household gas demand and its potential influencers, and they constrain comparisons of results across countries and over time within the same country. It is also worth noting that the 'lack of agreement' in the surveys of existing studies on the reported demand elasticities (cf. Vásquez et al., 2011; Dagher, 2012) should not be surprising and needs to be viewed by researchers as expected, as the relationship between prices and consumption levels is highly heterogeneous and constantly changes across and within countries, across and within households and across and within different time periods.

Another important methodological constraint is that the changes in total household consumption calculated here due to the price increase are estimated averages as they do not reflect potential changes in government expenditures over this period. These can reflect changes through potential increases or decreases in other subsidies, in public funding for social programmes, in levels of taxation etc. that could help mitigate or intensify possible household welfare losses. This is a methodological limitation facing all studies trying to assess the potential effects of price reforms on households due to measurement issues related to expenditure data collected at the household level while much public expenditure data is reflected at the macro level (and cannot be matched to those in household surveys). Other methodological factors – such as how surveys are designed, by which means data are collected, which research methods are selected and, among others, how data are interpreted – all lead to unavoidable variations in the reported relationships between prices and consumption levels across different studies. There are, when we dig deeper into the methods used, always fundamental constraints facing any such study related to statistical modelling, the theory of probabilistic causation and creating useful static variables for our models to try and capture dynamic phenomena in the real world. Taken together, the usefulness of cross-country comparisons of results and the usefulness of study results for other contexts (external validity) are thus constrained. In general, statistical accuracy is limited and uncertainty is always present, making estimations of elasticity not an 'economic law' or reflecting a definitive causal effect but they rather just illustrate how consumption and tariffs can be related in a statistical model (see also Krauss, 2015).

In spite of the methodological constraints we still need to inform policy with the available data, while acknowledging their important limitations and also being more modest about the possible scope of results. The main policy implication of the energy price reform in terms of efficiency and distribution is that the combination of an increased energy tariff with a targeted safety net to help compensate it for the poor can produce overall positive fiscal, environmental and poverty-reducing externalities. Even though governments may have limited influence on imported gas price increases they can implement mitigating measures for those households most affected and thereby help raise public acceptance for tariff reforms.

The government could in particular consider compensating higher gas costs among poor households – many of whom are family benefit recipients – during the four peak winter months (December to March) when average gas consumption is three times higher. This could present a viable, effective and efficient policy approach to mitigate potential adverse effects of the tariff reform, especially as such poorer households reduced their gas consumption more strongly than the average household. This policy measure, if targeted to family benefit households by increasing their beneficiary amounts, would be easiest to administer but it may only reach a marginal share of households in rural areas, as only 6.5% of family benefit recipient households in rural areas use gas to heat their home compared to 53.5% of recipient households in urban areas.[16] It is thus important for policymakers designing a mitigation strategy to consider whether non-family benefit households should also be reflected in the target group. Using the current family benefit scheme – or preferably a better targeted, more efficient version of the scheme – is nonetheless likely the most feasible approach relative to other policy measures such as life-line tariffs (which require low administrative capacity but are associated with high levels of leakage to the non-poor) or cash transfers allocated for energy (which can be cost-effective but often require very high levels of administrative and targeting capacity). Beyond ex-post social protection policies, a policy response within the energy sector that is needed is to diversify the country's energy portfolio, especially into renewable sources, as countries with greater energy resource diversification are less likely to be

[16] The Government of Armenia has legitimised using the family benefit programme as the largest policy mechanism in the country to target public resources to disadvantaged households, while bearing in mind that the programme only covers about 13% of all households in the country.

affected by international price changes like those experienced in Armenia. The government can also consider policies such as phasing in smaller price increases over time in the future so households can better cope with them, and also subsidising and/or obliging households to insulate their houses which can significantly reduce energy costs (Berkhout et al., 2004; Mitra and Atoyan, 2012).

It is overall important to stress that such evidence-based analyses are just one part of the larger policymaking process related to energy price reforms. It is equally important to consider other factors such as the available public resources needed to adopt a mitigation strategy; the potential scope of such a strategy in cushioning price shocks; levels of state capacity – statistical and administrative – to design, target and implement such a strategy well; the social acceptability among citizens of the subsidy reform and of the potential compensation strategy; the interests of lobby groups and gas companies that can benefit from higher prices; conditions in exporting countries that can spark frequent domestic gas price increases; and, among other factors, political prioritisation and policy sequencing for future reforms such as implementing some compensation strategy before reducing gas subsidies in order to increase public acceptability of the expected price increases. It is however beyond the scope of this paper focused on the potential effects of gas tariff increases on households to explore the financial and political feasibility of such policy responses relative to the expected benefits while taking into account such political economy and institutional constraints. At the same time, while increases in gas tariffs are critical to address environmental and fiscal concerns and improve energy service delivery, it is important for governments to take concrete measures to mitigate potential adverse effects of gas tariff reforms on poor households.

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Appendix A

Table A1
Summary statistics of variables used in regression model 1.

	Full sample				Urban		Rural		Family benefit recipients		Households below poverty line	
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Household gas consumption	7,346	8,369	100	220,000	7,315	8,211	7,432	8,785	5,910	5,643	5,182	4,586
Gas price (pre and post reform)	--	--	7.49	10.62	--	--	--	--	--	--	--	--
Total per capita consumption	371,997	347,640	20,660	18,300,000	387,698	395,805	340,852	219,959	282,954	196,687	195,955	80,370
Electricity consumption	4,574	3,656	0	77,000	4,822	3,645	4,082	3,628	3,787	2,765	3,865	2,671
LPG consumption	213	1,094	0	26,000	112	797	412	1,501	247	1,187	207	975
Wood consumption	167	3,891	0	200,000	39	990	420	6,568	238	3,212	11	507
Liquid fuel consumption	15	491	0	59,500	12	520	21	429	16	316	6	138
Urban	0.66	0.47	0	1	1.00	0.00	0.00	0.00	0.58	0.49	0.66	0.47
Households with 1 to 3 members	0.39	0.49	0	1	0.42	0.49	0.33	0.47	0.30	0.46	0.28	0.45
Households with 4 to 5 members	0.39	0.49	0	1	0.39	0.49	0.39	0.49	0.39	0.49	0.40	0.49
Households with 6 or more members	0.22	0.42	0	1	0.20	0.40	0.27	0.45	0.30	0.46	0.33	0.47
Floor area, m^2	71	36	8	500	61	30	92	38	65	33	68	35
Gas is main heating source	0.55	0.50	0	1	0.66	0.47	0.32	0.47	0.39	0.49	0.42	0.49
Centralized hot running water	0.43	0.49	0	1	0.56	0.50	0.17	0.38	0.24	0.43	0.27	0.44
Yerevan	0.34	0.47	0	1								
Aragatsotn	0.04	0.20	0	1								
Ararat	0.08	0.27	0	1								
Armavir	0.08	0.27	0	1								
Gegharkunik	0.07	0.25	0	1								
Lori	0.11	0.31	0	1								
Kotayk	0.09	0.28	0	1								
Shirak	0.09	0.29	0	1								
Sjunik	0.05	0.21	0	1								
Tavush	0.04	0.20	0	1								
Vayots Dzor	0.02	0.13	0	1								
Observations	11,196				7,282		3,914		1,185		3,021	

Source: All calculations based on data from ILCS, while gas price information is derived from Erra.

Table A2
Share of households with positive energy consumption by source.

	Total	Urban	Rural	Richest quintile	Poorest quintile
Gas consumption	78.3	86.4	62.3	84.2	69.1
Electricity consumption	98.8	99.0	98.5	99.0	97.4
LPG consumption	7.3	3.7	14.2	5.2	7.2
Wood consumption	0.3	0.1	0.7	1.0	0.0
Liquid fuel consumption	0.6	0.2	1.3	0.7	0.6
Observations	7,869	4,414	3,455	1,699	1,306

Source: Calculations based on data from ILCS.

Table A3
Summary statistics of variables used in regression model 2.

	Mean	Std. Dev.	Min	Max
Main heat source, gas	0.52	0.50	0	1
Main heat source, electricity	0.12	0.33	0	1
Main heat source, wood	0.28	0.45	0	1
Main heat source, other	0.06	0.24	0	1
Reform dummy (pre and post reform)	--	--	0	1
Total per capita consumption	394,895	385,266	20,660	18,300,000
Supplementary heat source, gas	0.04	0.19	0	1
Supplementary heat source, electricity	0.06	0.23	0	1
Supplementary heat source, wood	0.06	0.23	0	1
Supplementary heat source, other	0.07	0.25	0	1
Urban	0.66	0.47	0	1
Households with 1 to 3 members	0.40	0.49	0	1
Households with 4 to 5 members	0.39	0.49	0	1
Households with 6 or more members	0.21	0.41	0	1
Floor area, m^2	81	38	8	600
Yerevan	0.34	0.47	0	1
Aragatsotn	0.04	0.20	0	1
Ararat	0.08	0.27	0	1
Armavir	0.08	0.27	0	1
Gegharkunik	0.07	0.25	0	1
Lori	0.11	0.31	0	1
Kotayk	0.09	0.28	0	1
Shirak	0.09	0.29	0	1
Sjunik	0.05	0.21	0	1
Tavush	0.04	0.20	0	1
Vayots Dzor	0.02	0.13	0	1
Observations		15,744		

Source: Calculations based on data from ILCS.

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