CEDLAS

Facultad de Ciencias Económicas

UNIVERSIDAD NACIONAL DE LA PLATA

DOCUMENTOS DE TRABAJO

Energy Poverty on the Flip Side of Energy Subsidies

Julian Puig, Leonardo Gasparini y Jorge Puig

Documento de Trabajo Nro. 348

Abril, 2025

ISSN 1853-0168

www.cedlas.econo.unlp.edu.ar

Cita sugerida: Puig, J., L. Gasparini y J. Puig (2025). Energy Poverty on the Flip Side of Energy Subsidies. Documentos de Trabajo del CEDLAS Nº 348, Abril, 2025, CEDLAS-Universidad Nacional de La Plata.

Energy poverty on the flip side of energy subsidies*

Julian Puig Leonardo Gasparini Jorge Puig

Abstract

This paper examines the relationship between energy subsidies and energy poverty (EP). Understanding this relationship is important because subsidies are often justified from an equity perspective to protect the most vulnerable households. Argentina, which has subsidized residential energy consumption since the early 2000s, is used as the case study. Since then, the energy subsidy policy has experienced two well-defined phases: massive and universal subsidies until 2015, followed by an attempt at reduction and targeting. This context, combined with notable regional disparities -including variations in income levels, climatic conditions, energy prices, and residential energy consumption patterns (e.g., electricity vs. piped gas)- makes this case study particularly compelling. EP is analyzed both unidimensionally and multidimensionally. Under both measures, EP follows a U-shaped pattern that reflects the phases of energy subsidies: a significant decrease between 2005 and 2013, followed by a considerable increase by 2018. The paper also highlights the key role of regional disparities which is crucial for interpreting the results beyond the Argentine case. Based on the findings, the paper contributes with globally relevant insights on the link between energy subsidy policies and EP.

JEL Codes: I32, Q40, D30, H24
Keywords: energy poverty, electricity, gas, subsidies, Argentina.

*Julian Puig is the corresponding author and belongs to Center of Public Finance Studies (CEFIP), IIE-FCE, National University of La Plata (UNLP). Leonardo Gasparini and Jorge Puig belong to Center for Distributive, Labor, and Social Studies (CEDLAS), IIE-FCE-UNLP. Gasparini also belongs to National Academy of Economic Science of Argentina (ANCE) and CONICET. Jorge Puig also belong to CEFIP-IIE-FCE-UNLP. We would like to thank Fernando Navajas for valuable comments, and to seminar participants at Argentinean Economic Association (AAEP) Annual Meeting, and Jornadas Internacionales de Finanzas Publicas (Universidad Nacional de Cordoba, Argentina). The usual disclaimer applies. Email for contact: julian.puig@econo.unlp.edu.ar (corresponding author).

1 Introduction

Energy resources are key to improving social welfare (Birol, 2007; Ssennono *et al.*, 2021; Makridou *et al.*, 2024). However, access to affordable and quality energy supplies remains hindered by inequality of opportunities and a lack of energy resources for a large portion of the world's population. For example, in 2020, approximately 800 million people globally did not have access to electricity (World Bank, 2020). Additionally, populations with access to energy resources often face another critical challenge: affordability. Energy costs frequently represent a significant burden on household budgets. To address this, governments attempt to alleviate the burden of energy expenditures on households by subsidizing energy providers, enabling households to pay tariffs below the cost-recovery level for the energy they consume (Laderchi *et al.*, 2013; Rosas-Flores *et al.*, 2017).

Energy Poverty (EP) is closely related to the deprivation of essential energy resources, as it refers to the inability of households to inadequately meet their energy needs (Awaworyi Churchill & Smyth, 2021). In fact, EP can be divided into two dimensions: availability and affordability of energy sources[1]. These dimensions directly affects the measurement of EP, which can be either unidimensional or multidimensional. The unidimensional approach estimates EP through household energy budget shares. Boardman (1991)'s pioneering contribution established the Ten Percent Rule Index (TPRI): if a household's energy budget share exceeds 10%, it is considered energy poor. Alternatively, the multidimensional approach considers additional factors beyond energy expenditure. The most common indicator is the Multidimensional Energy Poverty Index (MEPI), developed by Nussbaumer *et al.* (2012), which analyzes household deprivations in dimensions such as physical access to energy, ownership of appliances, and energy affordability. Specifically, a household is considered energy poor if it exceeds a certain threshold of deprivations across these dimensions (Aristondo & Onaindia, 2018; Bezerra *et al.*, 2022).

As energy subsidies aim —among other goals— to alleviate energy inequality and poverty, particularly among low-income groups (Xu & Zhang, 2023), their relationship with EP becomes highly relevant. The objective of this paper is to contribute to a better understanding on this relationship. For this purpose, the paper relies on the case of Argentina, a country that has massively subsidized energy (i.e., electricity, natural gas, and fuels) in recent decades, significantly impacting the price of energy consumed by households. The energy subsidy policy, previously

[1] In developing countries, the central issue is the availability of basic energy resources, such as electricity (González-Eguino, 2015), while in developed economies, the main concern is the affordability of domestic energy services (Aristondo & Onaindia, 2018; Sy & Mokaddem, 2022).

studied by Hancevic *et al.* (2016) and Giuliano *et al.* (2020), has presented well-defined phases: (i) universal subsidies between 2002 and 2015; (ii) attempts at reduction and targeting from 2016 to 2019; and (iii) a return to tariff freezes and increased subsidies from late 2019 to 2023. Energy subsidies increased nearly sevenfold as a share of gross domestic product (GDP) in less than a decade, from 0.4% in 2005 to 2.8% in 2014. In 2019, subsidies were 1.1%, and they peaked again in 2021 at 2.1%, with subsidies at 1.4% of GDP in 2023 (Giuliano *et al.*, 2020; OPC, 2023; Bertín *et al.*, 2024a,b). In 2024, Argentina will once again begin a phase-out of energy subsidies.

In addtion to the energy subsidy policy, some other factors make the case of Argentina compelling for studing the relationship between subsidies and EP. For example, Argentina exhibits notable heterogeneities across various dimensions. Like many other developing countries, Argentina's population and production are highly concentrated in a few provinces (i.e., subnational units), which account for more than half of the national GDP (see Table A1 in the Appendix). Some provinces (mainly in the north) have historically had a per capita GDP around half the national average, while others (mainly in the south) have a per capita GDP about 70% higher than the national average (Porto, 2004; CEPAL, 2022). This allows the results for some of Argentina's provinces to provide insights applicable to a wide range of countries. For instance, Argentina's average GDP per capita was USD 13,935 in 2022. However, in the province of Tierra del Fuego, GDP per capita was USD 23,223, while in Misiones it was just USD 4,646. The GDP of Tierra del Fuego is comparable to that of Greece, Uruguay, or Barbados, whereas Misiones' GDP aligns with that of Indonesia, Ukraine, Jordan, or Tonga. Argentina also experiences significant temperature variations, with an average temperature of 21°C in a northern province like Catamarca and 7°C in a southern province like Santa Cruz. These disparities result in differing energy consumption patterns across provinces: for example, northern provinces are relatively more electricity-intensive, while southern provinces are more gas-intensive. In 2018, average annual gas consumption was 698 m^3 in Catamarca and 7,288 m^3 in Santa Cruz (see Table A1 in the Appendix). Additionally, price regulation differs by energy type: natural gas prices are set at the national level, while electricity prices are determined by the provinces (Giuliano *et al.*, 2020). These disparities in energy consumption types and price regulations can be significant factors in estimating EP.

The paper uses microdata from the three latest waves of the National Household Expenditure Survey (ENGHo) to provide a comprehensive analysis of EP's evolution from 2005 to 2018, capturing the different phases of energy subsidy policies. EP is estimated both unidimensionally and multidimensionally through the TPRI and the MEPI, respectively. The microdata also allow to inquire on the role of the regional disparities and the paper moves in this direction. In addition, the paper extends the analysis by examining the relationship between EP and monetary poverty, and how household characteristics affect the probability of being energy poor (Makridou *et al.*, 2024).

The findings indicate that both unidimensional and multidimensional EP followed a U-shaped pattern over the analyzed period: in 2005, EP under the TPRI was at 12.1%, decreased to 1.9% in 2013, and rose to 13.8% in 2018, largely reflecting the dynamics of energy prices as influenced by subsidy policies. Furthermore, the results reveal significant regional disparities in EP, driven by income levels, the household energy consumption mix (i.e., gas vs. electricity), and regional price variations. Specifically, southern provinces consume significantly more gas relative to electricity compared to the central and northern provinces. Additionally, southern provinces face lower unit prices for energy, which, along with higher income levels, contributes to their lower EP levels. For instance, in 2018 and considering the TPRI, EP ranged from 3.4% to 28.1% across provinces. Similar patterns were observed in the multidimensional approach. The key role of regional disparities is crucial for interpreting the results beyond the Argentine case. Additionally, there is a strong positive correlation between EP and monetary poverty. Certain household characteristics also appear to reduce the likelihood of being energy poor, including having a head of household with higher education, being married or retired, and living in an apartment or having access to public water and sewer networks.

The paper contributes in several ways. EP has been measured for Argentina by Lampis *et al.* (2022) and Burguillo *et al.* (2022), who document an EP rate ranging from 17% to 28%. Both studies measure EP for the year 2018 using only the TPRI. However, and surprisingly given the subsidy policy, these contributions do not capture the trend of EP over time and the different phases of the subsidy policy. Additionally, the lack of a multidimensional measurement makes it difficult to determine whether EP varies based on the methodology employed, and if so, how. Moreover, this paper's findings challenges previous research for Argentina suggesting that the geographical distribution of EP, when measured with the TPRI, is relatively homogeneous across regions (Lampis *et al.*, 2022). Finally, the relationship between monetary poverty and EP has also been echoed by previous literature on EP in Argentina.

Beyond advancing previous evidence on EP, it complements the extensive research on the distributional impacts of Argentina's energy subsidy policies. Several contributions show that subsidies are progressive (i.e., poorer sectors receive higher subsidies relative to their income) but with flaws in targeting (i.e., poorer sectors receive lower subsidies in absolute terms)(Lustig & Pessino, 2013; Puig & Salinardi, 2015; Lakner *et al.*, 2016; Hancevic *et al.*, 2016; Giuliano *et al.*, 2020; Bertín *et al.*, 2024a,b). In all this literature, the dimension of EP is completely omitted. Thus, this paper could also shed light on the link between EP and "energy populism", elaborated in Hancevic *et al.* (2016) for the Argentine case. Moreover, the paper not only deepens the analysis of

EP in Argentina but also contributes with conclusive evidence on the link between energy subsidy policy and EP. This adds to previous research on the broader implications of using energy pricing as a tool for income redistribution (Levinson & Silva, 2022). Additionally, the paper contributes to a more comprehensive view of EP in developing countries, particularly in Latin America, and aligns with similar studies conducted on Brazil (Bezerra *et al.*, 2022), Chile (Villalobos *et al.*, 2021), and Ecuador (Sinailin *et al.*, 2019). Estimates for EP in these countries, based on household surveys covering the period from 2014 to 2018, reveal EP rates between 10% and 15%, which are comparable to the findings in this paper for Argentina during the same period.

The remainder of this paper is organized as follows: Section 2 reviews the related literature, situates this paper within it, and contextualizes its contribution. Section 3 provides further context on the case study and its attractiveness to measuring EP over a long cycle of energy subsidies, with different phases, and in a country with marked regional disparities. Section 4 outlines the methodology and data. Section 5 presents the main findings, while Section 6 extends the analysis by examining the relationship between both measurements of EP, the relationship of EP with monetary poverty, and the household characteristics that influence the probability of being energy poor. Finally, Section 7 concludes with closing remarks.

2 Related literature

This paper contributes to the literature on energy subsidies and EP. On the measurement of this last concept, initially, Boardman (1991)'s pioneering contribution proposed an income-related unidimensional approach, which became one of the most widely adopted measures internationally (Ye & Koch, 2021). This measure is TPRI, which defines a household as experiencing EP if its energy budget share exceeds 10%[2]. Towards the second decade of the 2000s, measurements began to consider additional dimensions beyond household energy expenditure. In this context, Nussbaumer *et al.* (2012) proposed the MEPI, which became one of the most widely adopted indicators for multidimensional EP (Jayasinghe *et al.*, 2021a; Ssennono *et al.*, 2021)[3]. The MEPI

[2]This rule was based on the energy resources needed to maintain a satisfactory indoor temperature level. The minimum temperature thresholds ranged from 21° Celsius in sleeping rooms to 18° in other areas of the house. See Boardman (1991). Along these lines, Hills (2011) identifies EP with "low income and high costs" (i.e., LIHC), which means that a household pays more in energy costs than the median level, and its residual income places it below the official monetary poverty line (Che *et al.*, 2021). Note that LIHC is a relative measure, unlike the TPRI, which is an absolute one. For a discussion of strengths and weaknesses of these indicators, see Lampis *et al.* (2022).

[3]This measurement derives from the Oxford Poverty and Human Development Initiative (Che *et al.*, 2021) and from contributions that extend the estimation of monetary poverty to a multidimensional one, analyzing both

is useful for identifying different aspects in which a household may be deprived of energy, as it analyzes deprivations in terms of access to modern energy services. As this paper shows in Section 4, the MEPI captures both incidence (i.e., "headcount ratio") and intensity (i.e., "the poverty gap") of EP. The main dimensions considered by the MEPI include physical access to energy (e.g., connection to the electricity and gas grid), ownership of appliances, and energy affordability (i.e., energy expenditure). Under the MEPI measurement, a household is considered energy poor if it presents more than a certain number of deprivations in the considered dimensions (Bezerra *et al.*, 2022). In the context of unidimensional and multidimensional measurements, this paper presents estimates for Argentina based on both approaches, and definitely contributes with the second type of measurement.

Table 1 summarizes a literature review that contextualizes this paper's contribution. It can be noted that empirical evidence on EP is relatively recent, with most contributions belonging to the last decade. The evidence based on the TPRI supports a wide range for the EP rate (Panel A); contributions such as those for Ecuador and Chile, which are closely related to this paper, indicate that EP ranges between 8% and 15% (Sinailin *et al.*, 2019; Villalobos *et al.*, 2021). Additionally, the study for Ecuador also links EP to the existence of energy subsidies, arguing that these subsidies underestimate the actual household expenditure and, consequently, the EP. In line with this literature, this paper is closely related to Lampis *et al.* (2022), which reported an EP rate of 17% for 2018 in Argentina using the ENGHo and the TPRI. Two key observations apply regarding the comparison of EP levels between Lampis *et al.* (2022) and this paper. Firstly, the EP rate identified in this paper for 2018 is slightly lower, at 13.8%, compared to the 17% reported by Lampis *et al.* (2022). Secondly, and perhaps more notably, this paper highlights significant regional disparities in EP. In contrast, Lampis *et al.* (2022) suggests that when considering the TPRI, the geographical distribution of EP is somewhat more homogeneous between regions. Additionally, this paper is closely related to Burguillo *et al.* (2022), which also analyzes the TPRI for Argentina in 2018 and finds an EP rate of 28%. This rate is notably higher than the one documented in this paper. The divergence stems from a different definition of TPRI: while Burguillo *et al.* (2022) examines the share of energy expenditures in total household expenditure, this paper focuses on the share in total household income. Finally, it is worth noting that the measurements for 2018 do not capture any impact of energy subsidy policies. In this regard, the temporal analysis presented in this paper contributes significantly to understanding the trend of EP and the role that energy subsidies have played in shaping it.

incidence and intensity of EP (Chakravarty & D'Ambrosio, 2006; Alkire & Foster, 2011). For a conceptual review of monetary and multidimensional poverty, see Gasparini *et al.* (2013).

Regarding the evidence based on the MEPI (Panel B in Table 1), a similar range of EP rates can be observed. In fact, Nussbaumer *et al.* (2012) show that the incidence of EP is close to 100% for some low-income countries (e.g., African countries). Focusing again on Latin American and Caribbean countries, two aspects are worth highlighting. First, Chile and Ecuador have a multidimensional EP of 15% and 10%, respectively. This shows some correspondence between the TPRI and the MEPI. Second, based on the MEPI, Bezerra *et al.* (2022) present evidence for Brazil in line with the previous results, showing an EP rate of 10%. In this context, this paper presents evidence for Argentina that aligns in two aspects: (i) the EP level, considering the rate of 13.8% in 2018; and (ii) the correspondence of the results based on the TPRI with those based on the MEPI[4].

This paper is also closely related to the extensive literature on the distributive impact of energy subsidies in Argentina. For example, Lustig & Pessino (2013), Puig & Salinardi (2015), and Lakner *et al.* (2016) found that energy subsidies were not well-targeted, benefiting the non-poor more in absolute terms (i.e., subsidies were pro-rich), while relatively they were progressive, favoring the poor in relation to their income. This middle-to-high-income bias is linked to Argentina's "energy populism" by Hancevic *et al.* (2016). More recently, Giuliano *et al.* (2020) examined the 2016 subsidy reduction and the introduction of the social tariff aimed at protecting less well-off families. This study found that energy subsidies remained pro-rich and progressive, despite being lower in aggregate terms. Additionally, Bertín *et al.* (2024a,b) indicate that regional disparities in energy distribution costs and the pricing strategies of energy suppliers are critical factors driving the distributional incidence of subsidies. Moreover, ignoring the financing of subsidies can lead to an overestimation of their redistributive effect. In this context, this paper considers an aspect not addressed in all the previous literature on energy policy and welfare in Argentina. The EP estimates in this paper complement all previous analyses.

[4] Santillán *et al.* (2020) provides evidence for another set of Latin American countries (i.e., Colombia, Peru, Honduras, Mexico, etc.) where EP rates appear to be relatively higher. For example, in the case of Colombia, the EP rate is 29%. However, it should be clarified that the results presented in the review for the MEPI are not strictly comparable due to methodological differences. For instance, Bezerra *et al.* (2022) considers aspects related to the dimensions of physical access to energy, ownership of appliances, and energy service affordability, while Santillán *et al.* (2020) only considers the first two dimensions (i.e., omitting energy service affordability). In this context, this paper includes all three dimensions for Argentina, in line with Bezerra *et al.* (2022).

Table 1: Related literature on EP estimation, based on unidimensional and multidimensional approaches

Authors	Country	Methodology	Period	Results
Panel A. Unidimensional EP				
Okushima (2016)	Japan	TPRI	2004 - 2013	5% - 8%
Papada & Kaliampakos (2016)	Greece	TPRI	2015	58%
Sinailin *et al.* (2019)	Ecuador	TPRI	2014	8%
Sambodo & Novandra (2019)	Indonesia	TPRI	2016	53%
Villalobos *et al.* (2021)	Chile	TPRI	2017	15%
Lampis *et al.* (2022)	Argentina	TPRI	2018	17%
	Brazil	TPRI	2018	10%
Burguillo *et al.* (2022)	Argentina	TPRI	2018	28%
Panel B. Multidimensional EP				
	Namibia	MEPI	2007	66%
	Lesotho	MEPI	2009	84%
	Nigeria	MEPI	2008	79%
Nussbaumer *et al.* (2012)	Zambia	MEPI	2007	87%
	Sierra Leone	MEPI	2008	97%
	Malawi	MEPI	2010	97%
	Madagascar	MEPI	2009	98%
Aristondo & Onaindia (2018)	Spain	MEPIH	2004/15	5%/6%
Sinailin *et al.* (2019)	Ecuador	MEPI	2014	10%
	Haiti	MEPI	2018	98%
	Colombia	MEPI	2015	29%
	Guatemala	MEPI	2015	76%
Santillán *et al.* (2020)	Dom. Rep.	MEPI	2013	32%
	Honduras	MEPI	2012	72%
	Mexico	MEPI	2016	30%
	Peru	MEPI	2014	65%
Jayasinghe *et al.* (2021a)	Sri Lanka	MEPI	2016	71%
Ssennono *et al.* (2021)	Uganda	MEPI	2018	66%
Villalobos *et al.* (2021)	Chile	MEPI	2017	15%
Bezerra *et al.* (2022)	Brazil	MEPI	2002/18	10% (2018)

Source: Own elaboration based on cited references. *Note:* references with MEPIH only estimate the incidence rate (i.e., "headcount ratio") of the MEPI.

3 Argentina as an attractive case study

Argentina is an ideal country to study the relationship between energy subsidies and EP for several reasons. It is a federal country with four levels of government: the national level, the subnational level (which includes 23 provinces and the Autonomous City of Buenos Aires, or CABA), and over 2,300 local governments (Porto & Puig, 2023). As in many other developing countries, population and production are highly concentrated in a few provinces. Excluding CABA, four provinces (Buenos Aires, Córdoba, Santa Fe, and Mendoza) account for 60% of the total population, which is about 47 million people (Column 1, Table A1 in the Appendix). Additionally, more than half of Argentina's GDP is concentrated in these four provinces (Column 2, Table A1 in the Appendix), with just one province (Buenos Aires) contributing around 33% of the national GDP. The remaining 19 provinces (i.e., over 80% of the total number of provinces) tend to be sparsely populated and show a high degree of heterogeneity in various aspects (e.g., per capita GDP, productive structure, economic development, and social conditions). Some northern provinces, such as Chaco, Formosa, Misiones, and Santiago del Estero, have historically had a per capita GDP of about half the national average. In contrast, other southern provinces, such as Neuquén, Santa Cruz, and Tierra del Fuego, have the highest per capita GDP, up to 70% above the national average. Additionally, the capital, CABA, has a per capita GDP approximately three times the national average (Column 3, Table A1 in the Appendix). As mentioned in the Introduction, these regional disparities make the different provinces resemble a wide range of countries with different levels of development.

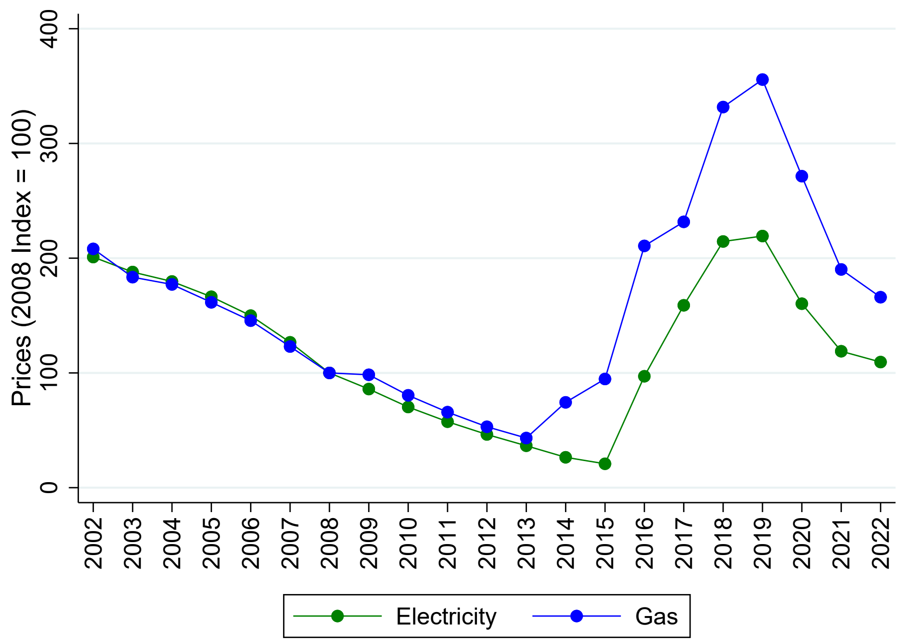
Argentina also presents significant climatic disparities across provinces, which have relevant implications for energy consumption. The northern provinces have average temperatures of around 20°C, while those in the south experience temperatures below 10°C (Column 5, Table A2 in the Appendix). This regional disparity is reflected in energy consumption patterns; specifically, the average annual gas consumption in some southern provinces is up to ten times that of the northern provinces (Columns 1 to 3, Table A2 in the Appendix). For instance, Jujuy, in the north, consumes about 600 m^3, while Neuquén and Tierra del Fuego, in the south, consume 3,714 m^3 and 7,073 m^3, respectively. These differences are less pronounced in electricity consumption: while Jujuy consumes about 207 kWh, Neuquén and Tierra del Fuego consume 152 kWh and 182 kWh, respectively. Thus, northern provinces are relatively more electricity-intensive, while southern provinces are more gas-intensive.

In addition to consumption patterns, heterogeneity in final energy prices is another relevant aspect of EP measurement. This variation arises from differences in regulatory frameworks. The national government regulates the gas market at the national level through the National Gas Regulatory Entity (ENARGAS). Meanwhile, the electricity market regulation is more decentralized: the national government has jurisdiction only over CABA and part of the Province of Buenos Aires through the National Electricity Regulatory Entity (ENRE). The remaining provinces have provincial entities regulating electricity market prices (Bertín *et al.*, 2024a). This makes electricity price differences more pronounced. Federal energy subsidies, which affect wholesale prices, result in diverse and, in some cases, unfavorable final prices for certain provinces due to factors like scale, efficiency, or regulatory differences (Giuliano *et al.*, 2020; Bertín *et al.*, 2024b).

Another key reason to analyze EP in Argentina is the long history of national government intervention in energy prices and tariffs to contain inflation, improve income distribution, and support certain productive activities (Cont *et al.*, 2019). Over the period from 2002 to 2022, residential energy prices were subject to varying degrees of state intervention. From 2002 to 2015, the government kept prices artificially low, reaching minimum values between 2013 and 2015 (Figure 1). This resulted in substantial energy subsidies, defined as the difference between the supplier's price, intended to cover energy production costs, and the final consumer's price. The government covered this difference through the national budget (Ministry of Energy, 2019). The impact on tariffs was significant: in 2015, for example, the average household electricity bill covered only about 12% of generation costs (Bertín *et al.*, 2024b). At the end of 2015, the new government aimed to reduce the fiscal impact of energy subsidies and introduced a gradual reduction plan from 2016 to 2019. This plan, justified on efficiency grounds due to low investment levels in energy infrastructure during the freezing period (Barril & Navajas, 2015), included a social tariff (i.e., a targeted subsidy) to protect low-income families. During this period, electricity prices rose by 377%, compared to a 171% increase in general prices (Giuliano *et al.*, 2020). By 2019, household electricity bills covered about 65% of generation costs (Bertín *et al.*, 2024b). However, by the end of 2019, Argentina faced a severe macroeconomic crisis and the incoming government enacted the "Law of Social Solidarity and Productive Reactivation" which froze energy tariffs again. This marked a new phase of tariff deterioration, with subsidies increasing once more. By 2022, household electricity bills covered only about 35% of generation costs (Bertín *et al.*, 2024b). Until today, energy subsidies have also been a major topic in Argentina. They were at the heart of the debates during the 2023 presidential campaign, and the incoming administration has announced plans to reduce subsidies from 2024 onwards.

Definitely, the combination of regional disparities in income, climatic conditions, consumption patterns, energy prices, and a subsidy policy extended over time with various phases, make Argentina an ideal case to explore EP.

Figure 1: Evolution of residential prices of electricity and gas. Years 2002-2022



Source: Own elaboration based on Center for Public Finance Studies (CEFIP-IIE-FCE-UNLP).

4 Methodology and data

Methodology. This paper first estimates the TPRI (Boardman, 1991). The energy sources considered are residential consumption of gas and electricity. Household expenditure on these energy services, GT_h^E, is defined by the sum of expenditure on electricity, piped gas, and bottled gas. GT_h^E as a share of the total household income (Y_h) denotes the household energy budget share (S_h^E). A household is defined as energy poor if $S_h^E = GT_h^E/Y_h \geq 10\%$. Sensitivity analysis explores alternative thresholds for this measure.

The paper then estimates the MEPI (Nussbaumer *et al.*, 2012) considering for three dimensions ($d = 3$) across all households in the country (n)[5]. First, **physical access (acc)** which is measured through two indicators: the use of modern fuels for cooking, and reliable access to electricity. Second **ownership of appliances (own)** which is measured through three indicators: ownership of communication devices (e.g., landline, mobile phone), access to information (e.g.,

[5]This approach closely follows Bezerra *et al.* (2022) and Jayasinghe *et al.* (2021b). As remarked in Section 2, other contributions consider alternative dimensions such as overdue payment of energy bills and the presence of deficiencies in household infrastructure such as roof leaks, broken windows, and wall dampness. See, for example, Aristondo & Onaindia (2018).

television, computer), and ownership of food preservation appliances (e.g., refrigerator, freezer). Third, **affordability (aff)** which is measured by a single indicator: energy expenditure based on the TPRI. Table 2 lists the variables used for each indicator in these dimensions. Households that do not meet a defined threshold for an indicator are considered deprived in that area. Indicators take binary values: 1 for deprivation and 0 for no deprivation.

The matrix $X = [x_{ij}]$ represents the sum of deprivations for each household i in dimension $j = \{acc, own, aff\}$. Each dimension j is weighted equally $w_{acc} = w_{own} = w_{aff} = 1/3$. Similarly, within each dimension, the indicators share the weight equally (e.g., the two previously described physical access indicators will each be weighted 1/6). A sensitivity analysis is also carried out by changing the weights of the dimensions and to determine the weight of each one this paper based on the methodology of Sadath & Acharya (2017), where $w_j = \frac{(d-r_j+1)^\rho}{\sum_{l=1}^{d}(d-r_l+1)^\rho}$ and $\sum_{j=1}^{d} w_j = 1$. These equations allow evaluating different combinations for w_j through an iterative approach for the dimensions using different values of ρ. Specifically, the methodology involves ranking the dimensions from highest to lowest relevance from 1 to 3 (r_j) and choosing a value of ρ to assign the selected weight w_j for each dimension. If equal weighting of the three dimensions is desirable, a value of ρ equal to 0 should be used, giving a weight of 1/3 to each dimension regardless of ranking[6]. This is the baseline case of this paper. Then, two scenarios are presented with different weighting to establish priority among the dimensions. Both prioritize physical access and differ in the second place of the ranking, alternating between affordability (case 2) and ownership of appliances (case 3). These weighting alternatives are presented in Table 3. It should be noted that within each dimension, as in the baseline case, the weight is equally distributed among the variables.

For each household i, c_i represents the weighted EP score defined as $c_i = \sum_{j=1}^{d} w_j x_{ij}$ where $\sum_{j=1}^{d} w_j = 1$. Then, each household presents a score equivalent to the sum of the weights of the indicators in which it presents deprivations. In the extreme, a household that presents deprivations in all indicators will have $c_i = 1$. In this context, a household is considered multidimensionally energy poor if its score c_i exceeds a specific deprivation threshold, $c_i > k$ where $0 < k < 1$. The higher the k, the more dimensions included to define a household as energy poor.

Previous estimates for the MEPI in Latin American countries prioritize access to electricity or modern energy fuels as the threshold that defines EP (Bezerra *et al.*, 2022). Thus, a household is considered energy poor if it does not have access to electricity for lighting or to electricity or gas for cooking. Therefore, in the baseline case of this paper, the adopted threshold is $k = 1/6$ to

[6] The higher the choice of ρ, the greater the difference between weights. If $\rho > 2$, the least weighted dimension becomes irrelevant in the analysis.

Table 2: Energy poverty indicators: associated variables, and thresholds

Dimension	Indicator	Variable	Threshold (deprived if)
Physical access	Use of modern fuels for cooking	Type of fuel for cooking	Uses wood or coal for cooking
	Reliable access to electricity	Connection to the electricity grid	No connection to the electricity grid
Ownership of appliances	Access to communication	Landline or mobile phone	No landline or mobile phone
	Access to information	TV or computer	No TV or computer
	Ownership of food preservation appliances	Refrigerator or freezer	No refrigerator or freezer
Affordability	Share of expenditure in total household income	$S_h^E = GT_h^E/Y_h$	$S_h^E = GT_h^E/Y_h \geq 10\%$

Source: Own elaboration based on Bezerra *et al.* (2022) and Jayasinghe *et al.* (2021b).

Table 3: Sensitivity analysis in the MEPI: alternatives weights for dimensions

Dimension	Baseline			case 2			case 3		
	ρ	Ranking	Weight	ρ	Ranking	Weight	ρ	Ranking	Weight
Physical access		-	1/3		1	1/2		1	1/2
Ownership of appl.	0	-	1/3	1	3	1/6	1	2	1/3
Affordability		-	1/3		2	1/3		3	1/6

Source: Own elaboration based on Bezerra *et al.* (2022) and Jayasinghe *et al.* (2021b). *Note*: The indicators within each dimension equally share the weight assigned to the dimension (i.e., in the baseline case: use of modern fuels for cooking (1/6), reliable access to electricity (1/6), access to communication (1/9), access to information (1/9), ownership of food preservation appliances (1/9), and share of expenditure in total household income (1/3)).

consider a household energy poor by this criteria (in cases 2 and 3, the adopted threshold adapts to this criteria, so $k = 1/4$ in both cases), which means that a household lacks at least one of the two physical access indicators. It should be noted that households using modern fuels for lighting and cooking, without a gas connection, are not deprived in the physical access dimension.

The index H is calculated, representing the share of households classified as energy poor. Being q the number of these households (where $c_i > k$), $H = q/n$ represents the incidence of multidimensional EP. In turn, A can be defined as the average of the censored weighted deprivation counts (i.e., $c_i(k)$), representing the intensity of multidimensional EP. More formally, $A = \sum_{i=1}^{n} \frac{c_i(k)}{q}$ is calculated. Thus, the MEPI captures information on both the incidence and intensity of EP and is defined as $MEPI = H * A$. Note that the MEPI ranges from 0 to 1, where 0 is the case of no energy poor. Otherwise, all households are poor ($H = 1$) and deprived in all dimensions ($A = 1$). Finally, it should be remarked that the MEPI is very sensitive to the choice of the threshold k and the weighting of the involved dimensions. The higher the k, the lower the share of energy poor households (H), while the intensity of poverty (A) increases since more deprivations are needed to be considered energy poor.

Data. Microdata from the National Household Expenditure Survey (ENGHo), published by the National Institute of Statistics and Censuses (INDEC), is the main source of information for this paper. This survey provides information on households' expenditures and incomes and contributes to define the basket of goods and services for the consumer price index (CPI). The survey covers all provinces in Argentina, which makes it possible to address regional disparities very well. This paper uses the three last available waves corresponding to the years 2004/2005, 2012/2013, and 2017/2018[7]. This makes it possible to capture the different phases of energy subsidy policy. The ENGHo surveys around 20,000 urban household and does not cover rural areas. When expanded, this sample represents the entire country[8]. In addition, the ENGHo reports information on physical access to energy sources, ownership of appliances, and energy service affordability. This information allows EP measurement for the entire country and also for each province, something relevant given the aforementioned regional disparities exposed in Section 3. The Appendix presents the description of each variable included in the MEPI estimation, and Tables A3, A4, A5, and A6 show detailed descriptive statistics of these variables.

[7] Hereinafter referred to as the years 2005, 2013, and 2018, as they represent the years of highest survey coverage.

[8] For example, the latest available wave (2018) represents approximately 12 million households and 40 million people.

5 Results

5.1 Unidimensional energy poverty

This subsection begins by presenting the findings for the TPRI. Table 4 indicates that EP follows a U-shaped pattern over time. Between 2005 and 2013, the proportion of energy-poor households decreased significantly from 12.1% to 1.9%. This decline corresponds with the observed decrease in prices shown in Figure 1, attributed to rising subsidies as described in Section 3. Furthermore, this price reduction was accompanied by a rise in household incomes due to economic growth during the period (Gasparini *et al.*, 2016; Alvaredo *et al.*, 2018; Bracco *et al.*, 2019; Lombardo *et al.*, 2022). To provide a clearer understanding of this trend, Table 5 outlines the average changes in energy expenditures, physical consumption, and household incomes. From 2005 to 2013, household spending on electricity and gas fell significantly (24.7% and 40.3%, respectively), while physical consumption increased (39.4% for electricity and 11.8% for gas). Household incomes grew by approximately 30% over this period.

However, this trend reversed by 2018, with the proportion of energy-poor households rising to 13.8% due to tariff adjustments and stagnating incomes. As subsidies decreased, household spending on gas and electricity surged by 274.6% and 161.3%, respectively, from 2013 to 2018 (Table 5). Meanwhile, physical gas consumption fell by 8.7%, and electricity consumption grew by only 6.7%. Household incomes, however, grew by less than 10%, resulting in the EP rate in 2018 surpassing that of 2005. This outcome is partly explained by the higher energy prices in 2018 relative to those in 2005 (see Figure 1).

Table 4 also provides a provincial breakdown of EP, showing a U-shaped pattern across all provinces but with considerable variation (between provinces) in EP levels. In 2018, CABA and Tierra del Fuego had the lowest EP rates (under 4%), while San Juan, Formosa, Chaco, and La Rioja had the highest rates (over 20%). The relatively low EP in CABA is likely due to its high income levels, which are roughly three times the national average per capita income, as discussed in Section 3. It is worth noting that this result challenges previous findings suggesting that the geographical distribution of EP, when measured with the TPRI, is relatively homogeneous across regions (Lampis *et al.*, 2022).

To further investigate the factors behind this provincial distribution of EP, Table 6 shows energy expenditures and physical consumption by province for 2018[9]. Energy expenditures are

[9] Appendix Tables A7 and A8 provide data for 2005 and 2013, respectively.

presented in local currency, and physical consumption is normalized and expressed in kilograms of oil equivalent (kep) for gas and electricity. This normalization facilitates the calculation of unit energy prices. Several important patterns emerge from this data. First, southern provinces (Neuquén, Río Negro, Chubut, Santa Cruz, and Tierra del Fuego) consume significantly more gas relative to electricity compared to the central (Buenos Aires, CABA, Cordoba, La Pampa, etc.) and northern (Salta, Jujuy, Chaco, Formosa, etc.) provinces. Second, southern provinces face lower unit prices for energy, which, along with higher income levels, contribute to their lower EP levels. For example, Tierra del Fuego and Santa Cruz, with the highest levels of energy consumption (mainly gas), have some of the lowest unit costs for gas ($0.8 and $1.3 per kep, respectively) and, consequently, exhibit low EP levels (Table 4). Therefore, the composition of energy expenditure (both prices and quantities) and regional income levels are crucial to understanding EP distribution across provinces.

Finally, the paper examines the sensitivity of the TPRI to variations in the threshold. TPRI is estimated for a range of thresholds from 5% to 15%, with incremental changes of 0.5 percentage points[10]. Figure 2 shows that the response to threshold changes is non-linear. Specifically, decreasing the threshold results in a faster increase in the number of energy-poor households than the decrease observed when raising the threshold. This effect is reflected in the steeper slope to the left of the reference line at the 10% threshold.

[10]EP values at different thresholds for each year are presented in Table A9 in the Appendix.

Table 4: Unidimensional EP: TPRI in Argentina, by province. Years 2005, 2013, and 2018. In percentage

	2005	2013	2018
Total country	**12.1**	**1.9**	**13.8**
CABA	1.9	0.3	3.4
Buenos Aires	12.0	1.6	14.2
Catamarca	10.5	1.3	16.0
Córdoba	12.9	4.2	17.3
Corrientes	23.0	2.2	11.6
Chaco	21.4	3.1	23.5
Chubut	6.6	3.6	19.1
Entre Ríos	12.3	3.1	18.6
Formosa	28.6	2.0	23.9
Jujuy	19.5	3.0	11.3
La Pampa	14.9	4.2	14.4
La Rioja	21.9	4.9	22.2
Mendoza	10.3	0.4	13.3
Misiones	16.9	3.1	15.3
Neuquén	18.3	4.1	8.8
Río Negro	11.3	3.1	10.0
Salta	14.5	2.4	17.6
San Juan	24.7	3.8	28.1
San Luis	10.3	1.0	15.4
Santa Cruz	5.6	1.2	11.7
Santa Fe	12.3	0.8	11.8
Santiago del Estero	12.7	2.5	17.3
Tucumán	11.1	1.5	14.5
Tierra del Fuego	2.8	2.8	3.9

Source: Own elaboration based on ENGHo 2005, 2013, and 2018. *Note:* All values are weighted using the population expansion factor.

Table 5: Growth rates of real expenditure on energy services (GT_h^E), total household income (Y_h), and energy services consumption levels. Years 2005-2018

Variable	2005/2013	2013/2018
Electricity expenditure	-24.7%	161.3%
Piped gas expenditure	-40.3%	274.6%
Electricity consumption	39.4%	6.7%
Gas consumption	11.8%	-8.7%
Total income	27.5%	9.3%

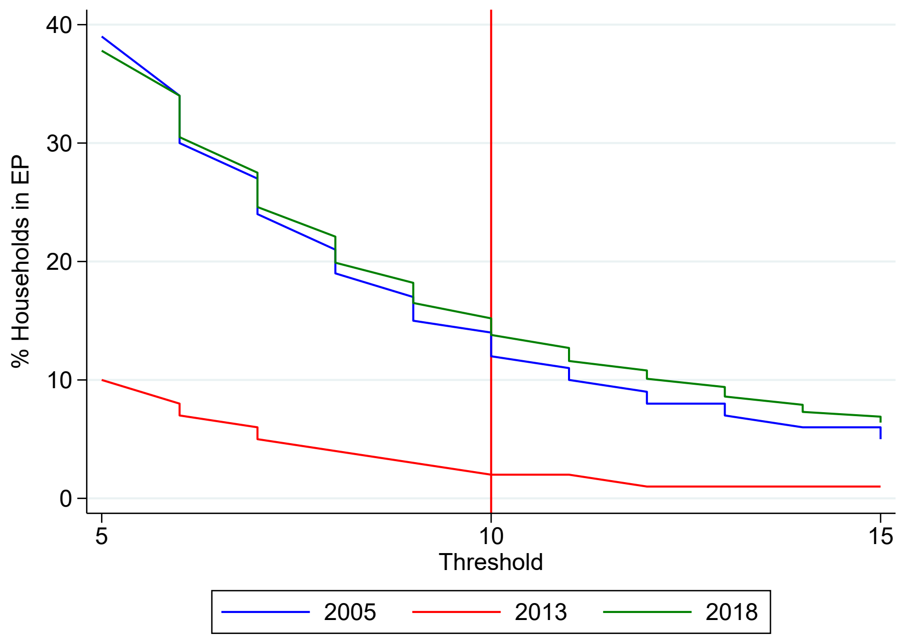
Source: Own elaboration based on ENGHo 2005, 2013, and 2018. *Note:* Due to data unavailability, bottled gas is not considered in the analysis. All values are weighted using the population expansion factor.

Table 6: Expenditure and consumption of piped natural gas and electricity by province in Argentina. Year 2018

	Expenditure (current $)		Consumption (kep)		$/kep	
Province	Gas	Electricity	Gas	Electricity	Gas	Electricity
CABA	401	517	47	23	8.5	22.3
Buenos Aires	655	652	69	22	9.6	30.2
Catamarca	613	843	48	24	12.7	34.9
Córdoba	801	721	59	24	13.6	29.5
Chubut	381	1.272	274	20	1.4	63.2
Entre Ríos	468	1.025	63	18	7.5	55.7
Jujuy	407	660	42	18	9.7	37.1
La Pampa	281	1.014	130	22	2.2	45.5
La Rioja	330	1.018	51	19	6.4	52.4
Mendoza	550	613	78	21	7.1	28.6
Neuquén	373	916	257	13	1.5	70.1
Río Negro	355	623	221	31	1.6	20.3
Salta	314	980	43	33	7.2	29.8
San Juan	512	1.223	60	21	8.5	59.0
San Luis	741	789	84	23	8.9	34.4
Santa Cruz	674	774	504	26	1.3	29.9
Santa Fe	581	803	55	19	10.5	42.8
Santiago del Estero	407	789	32	27	12.8	29.0
Tucumán	470	969	39	12	12.0	79.9
Tierra del Fuego	415	803	489	16	0.8	51.3

Source: Own elaboration based on ENGHo 2018, ENARGAS, and ADEERA. *Note:* The provinces of Formosa, Chaco, Corrientes, and Misiones are not included in the analysis as they do not have access to piped natural gas. For a comparable measure, m3 and kWh are converted into kilograms of oil equivalent (kep) (1 m3 = 0.83 kep and 1 kWh = 0.086 kep). All values are weighted using the population expansion factor.

Figure 2: Sensitivity analysis on the TPRI thresholds. Years 2005, 2013, and 2018. In percentage



Source: Own elaboration based on ENGHo 2005, 2013, and 2018. *Note:* All values are weighted using the population expansion factor.

5.2 Multidimensional energy poverty

This subsection continues by presenting the findings for the MEPI. As developed in Section 4, three alternative estimates are presented, each considering different weights for the MEPI dimensions. The baseline case, shown in Table 7, also exhibits a U-shaped pattern similar to that observed with the TPRI. Nationally, the incidence of EP decreased significantly from 20.0% in 2005 to 3.9% in 2013, in line with aggressive policy of energy subsidies. By 2018, however, EP increased to 14.8% as can be expected given the phase of energy subsidies removal. The MEPI, which reflects both incidence and intensity, also follows this U-shaped pattern, reaching 0.05 in 2018. In contrast to TPRI results, multidimensional EP in 2018 is lower than in 2005 (see Table 4). This difference arises because the MEPI considers additional factors such as access to services and appliances, which improved between 2005 and 2018. For example, the proportion of households without access to electricity fell from 2.0% in 2005 to just 0.2% in 2018, as shown in Tables A4, A5, and A6 in the Appendix.

In terms of regional variations, the U-shaped pattern persists across most provinces, affecting both the incidence and intensity of EP. In 2018, similar to the TPRI findings, provinces like CABA, Tierra del Fuego, Neuquén, and Santa Cruz have the lowest EP rates. In contrast, San Juan, Chaco, Formosa, and La Rioja have the highest. These findings emphasize the importance of the affordability dimension, which uniquely followed a U-shaped trend, unlike the continuous decline observed in access and appliance ownership from 2005 to 2018. This suggests that affordability is more susceptible to economic cycles, like fluctuations in income and energy service prices, while physical access and appliance ownership improvements relate more to long-term development. $k = 1/4$ To assess the importance of affordability, sensitivity analyses were conducted on the MEPI by varying the dimensional weightings and deprivation thresholds. Case 2 increases the weight on physical access and decreases it on appliance ownership while keeping affordability constant. The threshold remains at $k = 1/4$, defining energy-poor households as those lacking access to modern lighting and cooking. In contrast, Case 3 emphasizes physical access over affordability, with appliance ownership remaining unchanged. The threshold again is $k = 1/4$. Results for these cases are shown in Tables 8 and 9. Case 2 closely mirrors the baseline, showing similar trends with slightly lower EP incidence and MEPI scores, due to the reduced weight on appliance ownership, which generally has lower deprivation rates. Conversely, Case 3 diverges significantly; while EP drops between 2005 and 2013 as in the baseline, by 2018, it remains at 2013 levels. This results from the lower weight on affordability. Under this scenario, affordability alone is insufficient to classify households as energy-poor unless they also lack other dimensions. Consequently, with improvements in physical access and appliance ownership, EP stabilizes at low levels post-2013.

For Argentina, these results suggest that EP is largely driven by energy expenditures, as nearly 14% of households allocate over 10% of their income to energy services[11] Interestingly, high-consumption provinces like Tierra del Fuego, Santa Cruz, and Neuquén do not rank among the provinces with the highest EP, which aligns with TPRI findings. This underscores that lower energy prices and higher incomes effectively offset high consumption in these provinces.

[11]Refer to Table A6 in the Appendix.

Table 7: Multidimensional EP. Incidence and intensity of EP in Argentina with provincial breakdown. **Baseline Case**. Years 2005, 2013, and 2018

Province	Incidence (H)			Intensity (A)			MEPI (H*A)		
	2005	2013	2018	2005	2013	2018	2005	2013	2018
Total country	0.200	0.039	0.148	0.382	0.299	0.336	0.077	0.012	0.050
CABA	0.034	0.009	0.041	0.312	0.288	0.324	0.011	0.003	0.013
Buenos Aires	0.158	0.033	0.150	0.361	0.278	0.335	0.057	0.009	0.050
Catamarca	0.282	0.041	0.175	0.356	0.266	0.332	0.101	0.011	0.058
Córdoba	0.185	0.058	0.175	0.357	0.327	0.340	0.066	0.019	0.060
Corrientes	0.474	0.079	0.134	0.426	0.293	0.328	0.202	0.023	0.044
Chaco	0.456	0.095	0.280	0.424	0.317	0.343	0.193	0.030	0.096
Chubut	0.111	0.046	0.199	0.344	0.315	0.340	0.038	0.015	0.068
Entre Ríos	0.306	0.065	0.194	0.392	0.295	0.346	0.120	0.019	0.067
Formosa	0.489	0.080	0.265	0.444	0.335	0.329	0.217	0.027	0.087
Jujuy	0.361	0.057	0.128	0.423	0.325	0.344	0.153	0.019	0.044
La Pampa	0.234	0.048	0.152	0.368	0.347	0.331	0.086	0.017	0.050
La Rioja	0.317	0.080	0.234	0.411	0.306	0.342	0.130	0.025	0.080
Mendoza	0.149	0.012	0.139	0.363	0.288	0.333	0.054	0.003	0.046
Misiones	0.495	0.076	0.185	0.400	0.293	0.339	0.198	0.022	0.063
Neuquén	0.251	0.043	0.094	0.348	0.325	0.338	0.087	0.014	0.032
Río Negro	0.187	0.064	0.143	0.368	0.322	0.303	0.069	0.021	0.043
Salta	0.351	0.078	0.196	0.410	0.308	0.345	0.144	0.024	0.068
San Juan	0.352	0.053	0.297	0.391	0.318	0.340	0.137	0.017	0.101
San Luis	0.191	0.023	0.159	0.383	0.316	0.333	0.073	0.007	0.053
Santa Cruz	0.082	0.014	0.120	0.358	0.325	0.330	0.029	0.004	0.040
Santa Fe	0.157	0.021	0.125	0.371	0.289	0.335	0.058	0.006	0.042
Santiago del Estero	0.437	0.062	0.196	0.307	0.304	0.329	0.197	0.019	0.064
Tucumán	0.298	0.042	0.150	0.370	0.297	0.349	0.110	0.013	0.052
Tierra del Fuego	0.034	0.032	0.065	0.350	0.341	0.284	0.012	0.011	0.018

Source: Own elaboration based on ENGHo 2005, 2013, and 2018. *Note:* All values are weighted using the population expansion factor.

Table 8: Multidimensional EP. Incidence and intensity of EP in Argentina with provincial breakdown. **Case 2**. Years 2005, 2013, and 2018

Province	Incidence (H)			Intensity (A)			MEPI (H*A)		
	2005	2013	2018	2005	2013	2018	2005	2013	2018
Total country	0.165	0.028	0.143	0.389	0.330	0.338	0.064	0.009	0.048
CABA	0.019	0.005	0.038	0.346	0.340	0.334	0.007	0.002	0.012
Buenos Aires	0.131	0.022	0.144	0.362	0.319	0.337	0.048	0.007	0.049
Catamarca	0.221	0.032	0.167	0.372	0.315	0.336	0.082	0.010	0.056
Córdoba	0.154	0.054	0.175	0.366	0.332	0.339	0.056	0.018	0.059
Corrientes	0.418	0.046	0.130	0.431	0.334	0.335	0.180	0.015	0.043
Chaco	0.366	0.062	0.243	0.442	0.352	0.348	0.162	0.022	0.085
Chubut	0.085	0.042	0.194	0.357	0.329	0.340	0.030	0.014	0.066
Entre Ríos	0.224	0.045	0.187	0.425	0.330	0.342	0.095	0.015	0.064
Formosa	0.456	0.057	0.251	0.428	0.370	0.334	0.195	0.021	0.084
Jujuy	0.300	0.041	0.124	0.426	0.344	0.344	0.128	0.014	0.043
La Pampa	0.188	0.045	0.151	0.379	0.347	0.333	0.071	0.015	0.050
La Rioja	0.264	0.055	0.228	0.401	0.335	0.341	0.106	0.018	0.078
Mendoza	0.118	0.012	0.138	0.369	0.311	0.333	0.043	0.004	0.046
Misiones	0.451	0.055	0.177	0.404	0.325	0.340	0.182	0.018	0.060
Neuquén	0.194	0.043	0.090	0.363	0.329	0.338	0.070	0.014	0.031
Río Negro	0.140	0.032	0.136	0.377	0.338	0.324	0.053	0.011	0.044
Salta	0.281	0.059	0.191	0.416	0.338	0.346	0.117	0.020	0.066
San Juan	0.287	0.044	0.290	0.387	0.334	0.339	0.111	0.015	0.098
San Luis	0.145	0.014	0.156	0.390	0.359	0.334	0.057	0.005	0.052
Santa Cruz	0.059	0.012	0.117	0.364	0.333	0.333	0.021	0.004	0.039
Santa Fe	0.134	0.014	0.121	0.369	0.326	0.336	0.049	0.005	0.040
Santiago del Estero	0.407	0.053	0.183	0.459	0.327	0.336	0.187	0.017	0.062
Tucumán	0.218	0.027	0.148	0.391	0.345	0.343	0.085	0.009	0.051
Tierra del Fuego	0.028	0.032	0.060	0.354	0.337	0.321	0.010	0.011	0.019

Source: Own elaboration based on ENGHo 2005, 2013, and 2018.*Note:* All values are weighted using the population expansion factor.

Table 9: Multidimensional EP. Incidence and intensity of EP in Argentina with provincial breakdown. **Case 3**. Years 2005, 2013, and 2018

Province	Incidence (H)			Intensity (A)			MEPI (H*A)		
	2005	2013	2018	2005	2013	2018	2005	2013	2018
Total country	0.109	0.013	0.017	0.407	0.339	0.302	0.045	0.004	0.005
CABA	0.007	0.002	0.007	0.329	0.339	0.301	0.002	0.001	0.002
Buenos Aires	0.067	0.007	0.014	0.326	0.281	0.285	0.022	0.002	0.004
Catamarca	0.195	0.021	0.017	0.392	0.319	0.319	0.076	0.007	0.005
Córdoba	0.080	0.021	0.012	0.354	0.323	0.334	0.028	0.007	0.004
Corrientes	0.342	0.037	0.024	0.476	0.357	0.302	0.163	0.013	0.007
Chaco	0.278	0.051	0.057	0.520	0.375	0.326	0.145	0.019	0.019
Chubut	0.040	0.010	0.017	0.396	0.282	0.336	0.016	0.003	0.006
Entre Ríos	0.194	0.017	0.028	0.457	0.361	0.296	0.089	0.006	0.008
Formosa	0.329	0.047	0.029	0.494	0.436	0.284	0.162	0.021	0.008
Jujuy	0.257	0.024	0.028	0.441	0.340	0.335	0.113	0.008	0.009
La Pampa	0.112	0.006	0.013	0.386	0.426	0.281	0.043	0.003	0.004
La Rioja	0.215	0.013	0.033	0.374	0.347	0.305	0.081	0.005	0.010
Mendoza	0.066	0.010	0.010	0.353	0.315	0.287	0.023	0.003	0.003
Misiones	0.385	0.027	0.051	0.467	0.359	0.325	0.180	0.010	0.017
Neuquén	0.086	0.003	0.014	0.327	0.253	0.273	0.028	0.001	0.004
Río Negro	0.100	0.025	0.052	0.361	0.337	0.277	0.036	0.008	0.015
Salta	0.268	0.043	0.037	0.440	0.385	0.355	0.118	0.017	0.013
San Juan	0.212	0.011	0.039	0.355	0.331	0.293	0.075	0.004	0.011
San Luis	0.108	0.009	0.005	0.416	0.376	0.325	0.045	0.004	0.002
Santa Cruz	0.035	0.001	0.000	0.338	0.333	0.000	0.012	0.000	0.000
Santa Fe	0.064	0.007	0.011	0.352	0.387	0.283	0.022	0.003	0.003
Santiago del Estero	0.392	0.034	0.024	0.515	0.355	0.304	0.202	0.012	0.007
Tucumán	0.208	0.015	0.024	0.404	0.375	0.307	0.084	0.006	0.007
Tierra del Fuego	0.007	0.010	0.024	0.328	0.289	0.282	0.002	0.003	0.007

Source: Own elaboration based on ENGHo 2005, 2013, and 2018. *Note:* All values are weighted using the population expansion factor.

6 Extensions

6.1 Relationship between the TPRI and the MEPI

After examining both the unidimensional and multidimensional approaches to EP, and underscoring the significance of the TPRI (i.e., affordability dimension) within the MEPI framework for Argentina, this subsection explores the relationship between these two EP measures. Figure 3 displays the correlation plots for EP under the TPRI (vertical axis) and the alternative MEPI measures (horizontal axis). The different panels reveal a positive, high, and statistically significant correlation between the TPRI and the three MEPI cases analyzed. The correlation is strongest for the baseline case and case 2 (0.78 and 0.80, respectively), reflecting the higher weight of the affordability dimension in these scenarios compared to case 3.

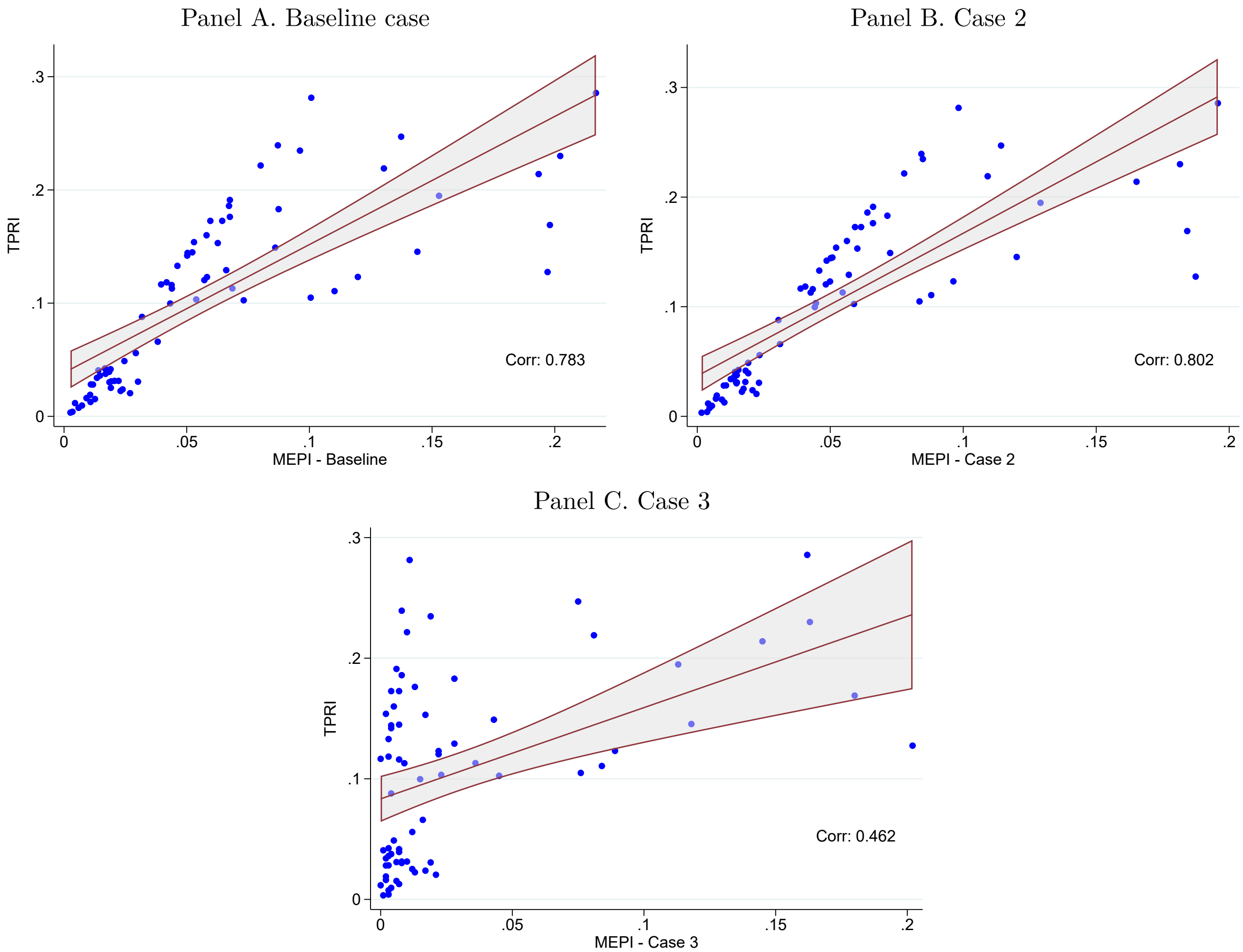
These results indicate that the TPRI and MEPI provide comparable estimates of EP in Argentina, suggesting that either measure can be effectively used to understand EP dynamics in the country. The strong correlation between them, particularly when affordability is weighted more heavily, reinforces the relevance of affordability as a key dimension of EP in the Argentine context.

6.2 Relationship between energy and monetary poverty

In the earlier sections, the influence of income levels on EP was highlighted, noting that households in high-income provinces, such as CABA or those in the south of Argentina, tend to experience lower EP rates. Given this, it is essential to examine the relationship between EP and monetary poverty, where income alone determines a household's vulnerability status (Gasparini *et al.*, 2013). For this analysis, official national and provincial data on monetary poverty from the National Institute of Statistics and Censuses (INDEC) are utilized.

Figure 4 presents correlation plots between monetary poverty and both unidimensional (TPRI) and multidimensional (MEPI) measures of EP. The different panels indicate a positive, strong, and statistically significant correlation, particularly when EP is measured using the multidimensional approach. The baseline MEPI case exhibits the highest correlation with monetary poverty, approximately 0.88. These findings suggest that monetary and energy poverty metrics provide comparable perspectives on household vulnerability, as they exhibit similar trends both in magnitude and direction. This underscores that income constraints are closely tied to EP in Argentina, reaffirming

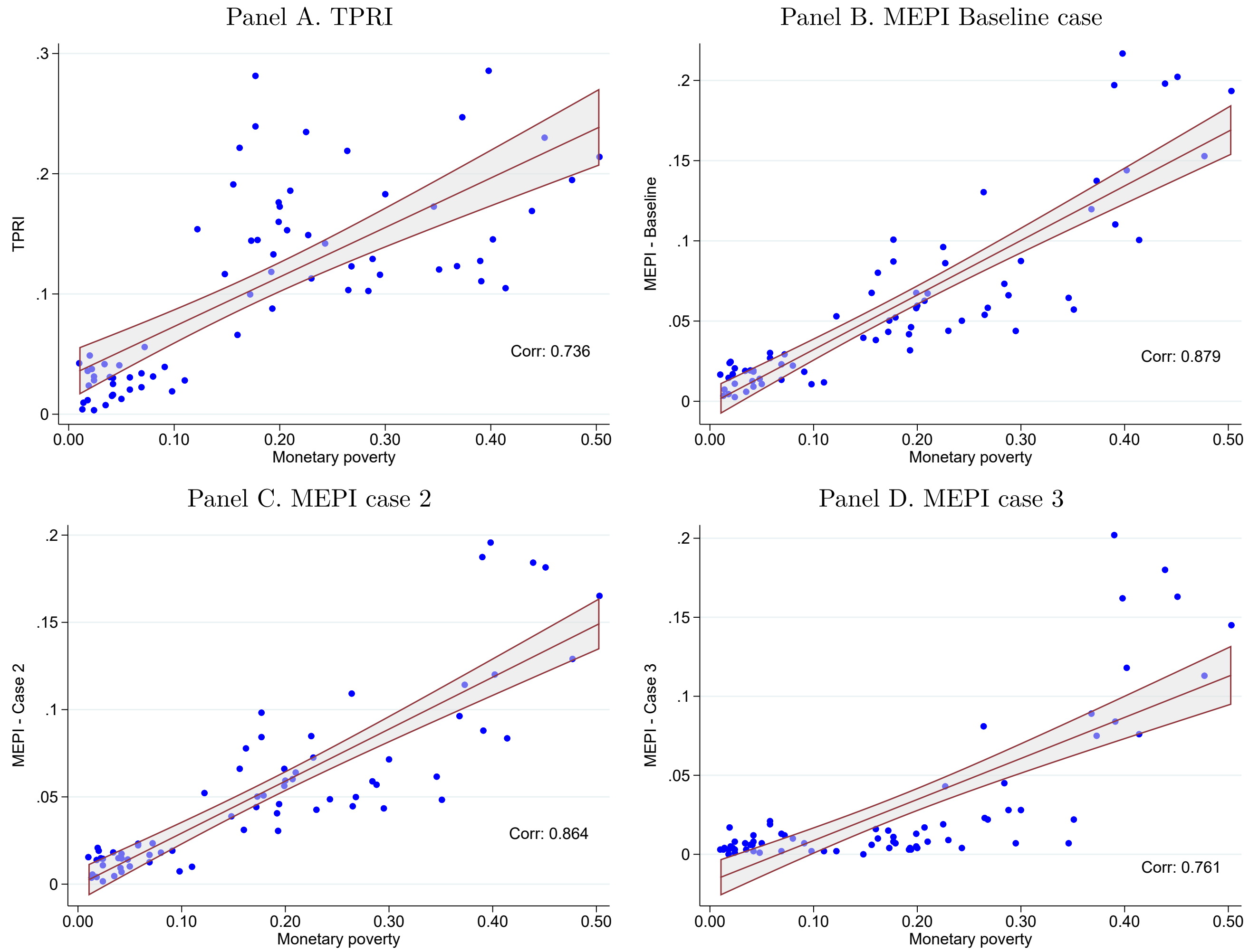
Figure 3: Relationship between the TPRI and the MEPI. Years 2005, 2013, and 2018



Source: Own elaboration based on ENGHo 2005, 2013, and 2018. *Note:* Grey areas denote confidence interval at 95%.

the importance of considering both dimensions in policy discussions.

Figure 4: Relationship between the TPRI, MEPI, and monetary poverty. Years 2005, 2013, and 2018



Source: Own elaboration based on ENGHo 2005, 2013, and 2018. *Note:* Grey areas denote confidence interval at 95%.

6.3 How household characteristics affect the probability of being energy poor?

To assess the household characteristics that increase the likelihood of experiencing EP[12], this subsection presents a probit model estimated through the following equation:

[12]See Makridou *et al.* (2024) for additional evidence on the factors influencing EP across European countries.

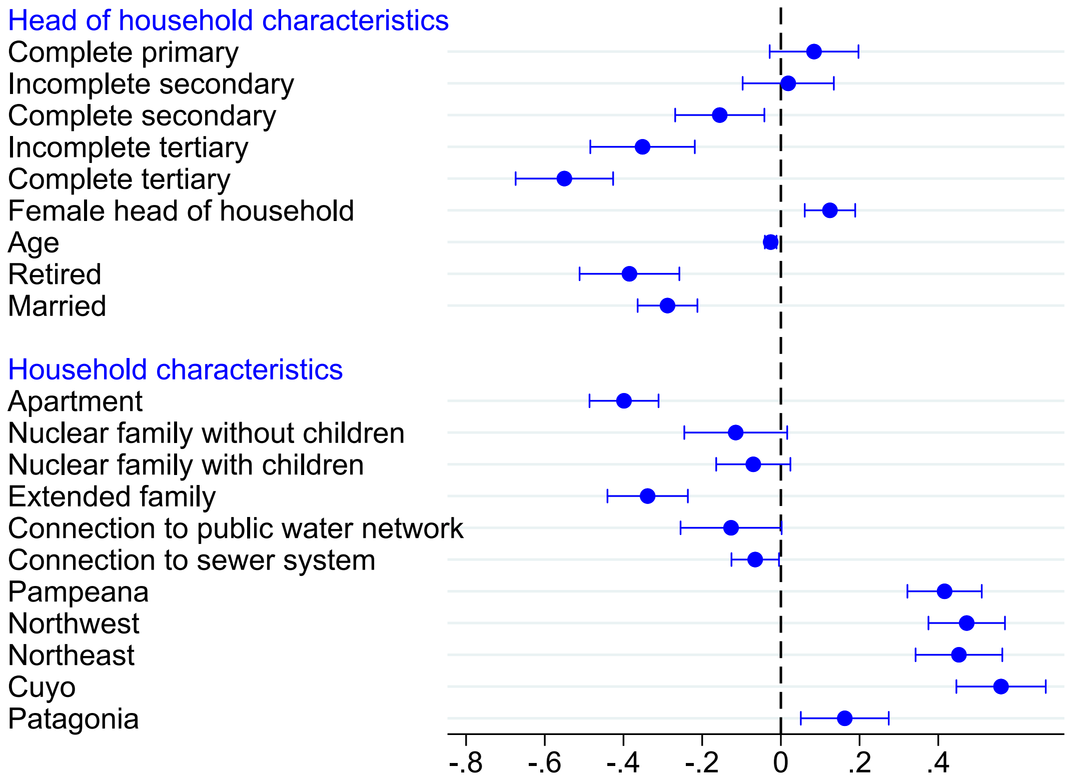
$$P(y_i = 1 \,|\, X) = \phi(B_0 + B_1 EduLevel_i + B_2 Gender_i + B_3 Age_i + B_4 Married_i + B_5 Retired_i + B_6 HouseType_i + B_7 HouseholdType_i + B_8 Region_i + B_9 Water_i + B_{10} Sewer_i + \epsilon_i) \tag{1}$$

Here, $P(y_i = 1, |, X)$ represents the probability of being energy poor, where y_i is a binary variable equal to 1 if the household is energy poor (using the TPRI as the main measure, although the results are robust when using the MEPI), and 0 otherwise. The explanatory variables (X) cover both characteristics of the household head and the household itself. These include the head's educational level, gender, age, marital status, and retirement status, as well as dwelling type, household composition, region, and access to public water and sewerage services. Descriptive statistics for these variables are detailed in Table A10 in the Appendix.

Figure 5 displays the marginal effects from the probit model. Results indicate that higher educational attainment for the household head reduces the likelihood of being energy poor, likely due to the income advantages associated with education (Angrist & Keueger, 1991; Card, 1999). Similarly, being married or retired decreases the probability of EP, in line with findings on income stability associated with these conditions (Cohen & Haberfeld, 1991; Antonovics & Town, 2004; Pilossoph & Wee, 2021). A gender disparity is observed, where households headed by women have a higher probability of EP, consistent with the wage gap that often results in lower incomes for women (Goldin, 2014; Gasparini & Marchionni, 2015).

Regarding household characteristics, living in an apartment is associated with a lower probability of EP compared to a house, possibly due to typically lower energy expenditures in apartments. Households connected to public water and sewerage also have a reduced likelihood of EP. Larger households, such as extended families, have a lower probability of EP than single-person households, likely reflecting economies of scale in energy consumption. Finally, regional differences are significant, with households in Greater Buenos Aires (including CABA) and Patagonia showing lower EP rates. This set of results is consistent with income correlations, as shown in Table A11, where the average incomes for these categories generally exceed those of the omitted categories. These findings highlight that household characteristics associated with higher income levels tend to reduce the likelihood of EP.

Figure 5: Estimation of marginal effects of a Probit model on the probability of being energy poor. Year 2018



Source: Own elaboration based on ENGHo 2018. *Note:* bands denote confidence interval at 95%.

7 Conclusion and policy implications

This paper contributes to a better understanding on the relationship between energy subsidies and EP. In addition, adds to the limited body of evidence on EP in Latin America, specifically through a detailed analysis of the case of Argentina. This country provides a unique study context due to its regional disparities, which manifest in varying income levels, climatic conditions, and residential energy consumption patterns. Furthermore, regulatory frameworks have led to significant regional price differences. Additionally, Argentina's energy policy, marked by substantial subsidies and subsequent tariff adjustments, offers a compelling backdrop for studying EP. This paper utilizes well-established unidimensional and multidimensional techniques to measure EP, leveraging the latest available household survey data for Argentina. This enables a comprehensive examination of EP across distinct phases of the tariff cycle.

The findings reveal a U-shaped pattern in both unidimensional and multidimensional EP over the analyzed period, strongly reflecting the influence of energy subsidies policies on EP. Significant regional disparities emerge, shaped by income levels, energy consumption types (gas vs. electricity), and regional price variations. The analysis also demonstrates a strong correlation between the TPRI and MEPI measures of EP, as well as between EP and monetary poverty. Household characteristics, generally linked to income, appear to reduce the likelihood of EP, such as having a higher-educated household head, being married or retired, living in an apartment, or having access to public water and sewer networks.

However, these findings are subject to certain methodological and data limitations. Methodologically, while the MEPI results align with previous studies, they may be constrained by the selected dimensions and weights (Bezerra *et al.*, 2022). As this study aims for comparability with existing literature, it adopts the most commonly used dimensions and weights. Future research could expand on this by exploring additional dimensions. On the data side, a notable limitation is that Argentina's most recent survey data is from 2018, meaning that the paper's estimates may not fully capture current EP trends amid ongoing fluctuations in energy subsidy policies. Despite this, the study's focus on a tariff cycle determined by evolving energy policies allows it to fulfill its objective and sets the stage for updated analyses when newer data becomes available.

Overall, the results yield key policy implications concerning the design, sustainability, and long-term impacts of residential energy subsidies. The findings underscore that sharp fluctuations in final energy prices significantly impact EP and household welfare, necessitating strategies to mitigate such volatility. In this sense, this paper sheds light on how "energy populism" (Hancevic *et al.*, 2016) can affect EP. Additionally, the analysis reveals the complexities of designing energy policies in a federal country like Argentina, where regional heterogeneities are pronounced. The differences in energy consumption types and regional price discrepancies play a crucial role in EP, suggesting that an adequate regulatory framework could be crucial to help alleviate these disparities.

Lastly, the study suggests that energy policy should address both cyclical and structural elements. Structural factors, like improving physical access to energy, are critical for reducing structural EP. Meanwhile, cyclical factors, some of which are linked to external variables beyond the policemaker's control, should be carefully managed by avoiding unsustainable policies in the long run and ensuring prices reflect actual costs. Previous literature alert on the broader implications of using energy pricing as a tool for income redistribution, as it may not effectively address income inequality (Levinson & Silva, 2022). In the same spirit, this paper can alert too on the implications of using energy pricing as a tool for reducing EP.

References

Alkire, Sabina, & Foster, James. 2011. Counting and multidimensional poverty measurement. *Journal of Public Economics*, **95**(7-8), 476–487.

Alvaredo, Facundo, Cruces, Guillermo, & Gasparini, Leonardo. 2018. A short episodic history of income distribution in Argentina. *Latin American Economic Review*, **27**(1), 1–45.

Angrist, Joshua D., & Keueger, Alan B. 1991. Does Compulsory School Attendance Affect Schooling and Earnings? *The Quarterly Journal of Economics*, **106**(4), 979–1014.

Antonovics, Kate, & Town, Robert. 2004. Are All the Good Men Married? Uncovering the Sources of the Marital Wage Premium. *American Economic Review*, **94**(2), 317–321.

Aristondo, Oihana, & Onaindia, Eneritz. 2018. Counting energy poverty in Spain between 2004 and 2015. *Energy Policy*, **113**, 420–429.

Awaworyi Churchill, Sefa, & Smyth, Russell. 2021. Energy poverty and health: Panel data evidence from Australia. *Energy Economics*, **97**(C), S0140988321001249.

Barril, Diego, & Navajas, Fernando. 2015. Natural Gas Supply Behavior under Interventionism: The Case of Argentina. *The Energy Journal*, **0**(Number 4).

Bertín, Octavio, García, Thomas, Pizzi, Francisco, Porto, Alberto, Puig, Julian, & Puig, Jorge. 2024a. Energy subsidies: conceptual framework and measurement for distributional impacts in Argentina. *Energy for Sustainable Development*, **83**, 101557.

Bertín, Octavio, García, Thomas, Pizzi, Francisco, Porto, Alberto, Puig, Julian, & Puig, Jorge. 2024b (June). *Revisiting Distributional Effects of Energy Subsidies in Argentina*. CEDLAS, Working Papers 0331. CEDLAS, Universidad Nacional de La Plata.

Bezerra, Paula, Cruz, Talita, Mazzone, Antonella, Lucena, André F.P., De Cian, Enrica, & Schaeffer, Roberto. 2022. The multidimensionality of energy poverty in Brazil: A historical analysis. *Energy Policy*, **171**, 113268.

Birol, Fatih. 2007. Energy Economics: A Place for Energy Poverty in the Agenda? *The Energy Journal*, **Volume 28**(Number 3), 1–6.

Boardman, Brenda. 1991. *Fuel poverty: from cold homes to affordable warmth*. Pinter Pub Limited.

Bracco, Jessica, Gasparini, Leonardo, & Tornarolli, Leopoldo. 2019. Explorando los cambios de la pobreza en Argentina: 2003-2015. *Económica*, **65**(January-D), 69–124.

Burguillo, Mercedes, Barisone, Manuela, & Juez-Martel, Pedro. 2022. Which cooking and heating fuels are more likely to be used in energy-poor households? Exploring energy and fuel poverty in Argentina. *Energy Research and Social Science*, **87**, 102481.

Card, David. 1999. The causal effect of education on earnings. *Chap. 30, pages 1801–1863 of:* Ashenfelter, O., & Card, D. (eds), *Handbook of Labor Economics*. Handbook of Labor Economics, vol. 3. Elsevier.

CEPAL. 2022. Desagregación provincial del valor agregado bruto de la Argentina, base 2004. *Repositorio digital, CEPAL.*

Chakravarty, Satya R., & D'Ambrosio, Conchita. 2006. The Measurement Of Social Exclusion. *Review of Income and Wealth*, **52**(3), 377–398.

Che, Xiahui, Zhu, Bangzhu, & Wang, Ping. 2021. Assessing global energy poverty: An integrated approach. *Energy Policy*, **149**, 112099.

Cohen, Yinon, & Haberfeld, Yitchak. 1991. Why do married men earn more than unmarried men? *Social Science Research*, **20**(1), 29–44.

Cont, Walter, Navajas, Fernando, Pizzi, Francisco, & Porto, Alberto. 2019. *Precios y tarifas y política económica: Argentina 1945-2019.* Centro de Estudios en Finanzas Públicas, Facultad de Ciencias Económicas, Universidad Nacional de La Plata.

Gasparini, Leonardo, & Marchionni, Mariana. 2015 (June). *Bridging Gender Gaps? The Rise and Deceleration of Female Labor Force Participation in Latin America: An overview.* CEDLAS, Working Papers 0185. CEDLAS, Universidad Nacional de La Plata.

Gasparini, Leonardo, Ciccowiez, Martín, & Escudero, Walter Sosa. 2013. Pobreza y desigualdad en América Latina: Conceptos, Herramientas y Aplicaciones. *Temas.*

Gasparini, Leonardo, Cruces, Guillermo, & Tornarolli, Leopoldo. 2016 (May). *Chronicle of a Deceleration Foretold: Income inequality in Latin America in the 2010s.* CEDLAS, Working Papers 0198. CEDLAS, Universidad Nacional de La Plata.

Giuliano, Fernando, Lugo, Maria Ana, Masut, Ariel, & Puig, Jorge. 2020. Distributional effects of reducing energy subsidies: Evidence from recent policy reform in Argentina. *Energy Economics*, **92**, 104980.

Goldin, Claudia. 2014. A Grand Gender Convergence: Its Last Chapter. *American Economic Review*, **104**(4), 1091–1119.

González-Eguino, Mikel. 2015. Energy poverty: An overview. *Renewable and Sustainable Energy Reviews*, **47**, 377–385.

Hancevic, Pedro, Cont, Walter, & Navajas, Fernando. 2016. Energy populism and household welfare. *Energy Economics*, **56**, 464–474.

Hills, John. 2011. *Fuel Poverty: The problem and its measurement. Interim Report of the Fuel Poverty Review.* CASE Reports. Centre for Analysis of Social Exclusion, LSE.

Jayasinghe, Maneka, Selvanathan, E.A., & Selvanathan, Saroja. 2021a. Energy poverty in Sri Lanka. *Energy Economics*, **101**(C).

Jayasinghe, Maneka, Selvanathan, E.A., & Selvanathan, Saroja. 2021b. Energy poverty in Sri Lanka. *Energy Economics*, **101**(C), S0140988321003388.

Laderchi, Caterina Ruggeri, Olivier, Anne, & Trimble, Chris. 2013. *Balancing Act : Cutting Energy Subsidies While Protecting Affordability.* World Bank Publications - Books, no. 12296. The World Bank Group.

Lakner, Christoph, Lugo, Maria Ana, Puig, Jorge, Salinardi, Leandro, & Viveros, Martha. 2016 (Aug.). *The Incidence of Subsidies to Residential Public Services in Argentina: The Subsidy System in 2014 and Some Alternatives.* CEDLAS, Working Papers 0201. CEDLAS, Universidad Nacional de La Plata.

Lampis, Andrea, Ibañez Martín, María María, Zabaloy, María Florencia, Schirmer Soares, Raiana, Guzowski, Carina, Mandai, Silvia Sayuri, Lazaro, Lira Luz Benites, Hermsdorff, Sonia Maria G.L., & Bermann, Célio. 2022. Energy transition or energy diversification? Critical thoughts from Argentina and Brazil. *Energy Policy*, **171**, 113246.

Levinson, Arik, & Silva, Emilson. 2022. The Electric Gini: Income Redistribution through Energy Prices. *American Economic Journal: Economic Policy*, **14**(2), 341–365.

Lombardo, Carlo, Ramirez-Veira, Lucía, & Gasparini, Leonardo. 2022 (Sept.). *Does the Minimum Wage Affect Wage Inequality? A Study for the Six Largest Latin American Economies.* CEDLAS, Working Papers 0302. CEDLAS, Universidad Nacional de La Plata.

Lustig, Nora, & Pessino, Carola. 2013 (Jan.). *Social spending and income redistribution in Argentina during the 2000s: The rising noncontributory pensions.* Commitment to Equity (CEQ) Working Paper Series 05. Tulane University, Department of Economics.

Makridou, Georgia, Matsumoto, Ken'ichi, & Doumpos, Michalis. 2024. Evaluating the energy poverty in the EU countries. *Energy Economics*, **140**, 108020.

Ministry of Energy. 2019. Balance de gestión en energía 2016—2019. Emergencia, normalización y bases para la transformación. *Ministry of Productive Development of Argentina.*

Nussbaumer, Patrick, Bazilian, Morgan, & Modi, Vijay. 2012. Measuring energy poverty: Focusing on what matters. *Renewable and Sustainable Energy Reviews*, **16**(1), 231–243.

Okushima, Shinichiro. 2016. Measuring energy poverty in Japan, 2004–2013. *Energy Policy*, **98**(C), 557–564.

OPC. 2023. *Monitor de Subsidios a la Energía de la Administración Nacional.* https://www.opc.gob.ar/monitores-fiscales/monitor-de-subsidios-a-la-energia-de-la-administracion-nacional/. Oficina de Presupuesto del Congreso.

Papada, Lefkothea, & Kaliampakos, Dimitris. 2016. Measuring energy poverty in Greece. *Energy Policy*, **94**(C), 157–165.

Pilossoph, Laura, & Wee, Shu Lin. 2021. Household Search and the Marital Wage Premium. *American Economic Journal: Macroeconomics*, **13**(4), 55–109.

Porto, Alberto. 2004. *Disparidades Regionales y Federalismo Fiscal.* EDULP.

Porto, Alberto, & Puig, Jorge. 2023. Fiscal Federalism: The Interaction between Own Revenues and Intergovernmental Transfers in Local Governments—The Case of Municipalities in Buenos Aires. *Publius: The Journal of Federalism.*

Puig, Jorge, & Salinardi, Leandro. 2015 (May). *Argentina y los subsidios a los servicios públicos: un estudio de incidencia distributiva.* CEDLAS, Working Papers 0183. CEDLAS, Universidad Nacional de La Plata.

Rosas-Flores, Jorge Alberto, Bakhat, Mohcine, Rosas-Flores, Dionicio, & Fernández Zayas, José Luis. 2017. Distributional effects of subsidy removal and implementation of carbon taxes in Mexican households. *Energy Economics*, **61**(C), 21–28.

Sadath, Anver, & Acharya, Rajesh. 2017. Assessing the extent and intensity of energy poverty using Multidimensional Energy Poverty Index- Empirical evidence from households in India. *Energy Policy*, **102**(03), 540– 548.

Sambodo, Maxensius Tri, & Novandra, Rio. 2019. The state of energy poverty in Indonesia and its impact on welfare. *Energy Policy*, **132**(C), 113–121.

Santillán, Oscar S., Cedano, Karla G., & Martínez, Manuel. 2020. Analysis of Energy Poverty in 7 Latin American Countries Using Multidimensional Energy Poverty Index. *Energies*, **13**(7), 1–19.

Sinailin, Quishpe Sinailin Pablo Quishpe, de La Paz, Paloma Taltavull, & Tárraga, Francisco Juárez. 2019. Energy Poverty in Ecuador. *Sustainability*, **11**(22), 1–19.

Ssennono, Vincent Fred, Ntayi, Joseph M., Buyinza, Faisal, Wasswa, Francis, Aarakit, Sylvia Manjeri, & Mukiza, Chris Ndatira. 2021. Energy poverty in Uganda: Evidence from a multidimensional approach. *Energy Economics*, **101**(C).

Sy, Saidou Abdoulaye, & Mokaddem, Lamia. 2022. Energy poverty in developing countries: A review of the concept and its measurements. *Energy Research Social Science*, **89**, 102562.

Villalobos, Carlos, Chávez, Carlos, & Uribe, Adolfo. 2021. Energy poverty measures and the identification of the energy poor: A comparison between the utilitarian and capability-based approaches in Chile. *Energy Policy*, **152**, 112146.

World Bank. 2020. *Report: Universal Access to Sustainable Energy Will Remain Elusive Without Addressing Inequalities.* Press release No: 2021/159/EEX, World Bank.

Xu, Shang, & Zhang, Jun. 2023. The welfare impacts of removing coal subsidies in rural China. *Energy Economics*, **118**(C).

Ye, Yuxiang, & Koch, Steven F. 2021. Measuring energy poverty in South Africa based on household required energy consumption. *Energy Economics*, **103**, 105553.

A Appendix

Table A1: Descriptive statistics of Argentine provinces. Demographic, economic, and climatic variables. Year 2021

	[1]	[2]	[3]	[4]	[5]
Province	Population (%)	GDP (%)	Per capita GDP ($)	Pop. density (inhab/km^2)	Average temperature (°C)
CABA	6.8	19.8	2949274	15161.3	18.6
Buenos Aires	38.2	32.5	589920	57.3	18.6
Catamarca	0.9	0.6	598567	4.2	21.0
Córdoba	8.6	7.7	898794	23.3	17.1
Corrientes	2.6	1.9	727541	13.6	21.6
Chaco	2.5	1.0	420411	11.3	21.4
Chubut	1.3	1.7	1332100	2.6	14.1
Entre Ríos	3.1	3.2	1059139	18.2	18.7
Formosa	1.3	0.7	524842	8.0	22.4
Jujuy	1.7	1.2	677312	15.2	18.9
La Pampa	0.8	1.0	1216978	2.5	16.2
La Rioja	0.8	0.8	987922	4.2	20.3
Mendoza	4.4	3.5	797094	13.7	17.5
Misiones	2.8	1.0	373466	42.8	22.2
Neuquén	1.6	2.7	1752598	7.5	15.3
Río Negro	1.7	1.6	976907	3.7	14.9
Salta	3.1	2.1	669009	9.3	16.8
San Juan	1.8	1.1	652791	9.3	17.9
San Luis	1.2	1.6	1348249	7.2	17.7
Santa Cruz	0.7	1.0	1402494	1.4	7.9
Santa Fe	7.7	8.6	1119821	26.6	19.4
Santiago del Estero	2.3	1.2	530423	7.7	20.6
Tucumán	3.7	2.9	800069	76.7	19.8
Tierra del Fuego	0.4	0.7	1708874	0.2	6.2
Total	100.0	100.0	1016025	12.5	18.6

Source: own elaboration based on CEPAL (2022) and INDEC.

Table A2: Annual consumption of network gas in m3 and monthly electricity in kWh at the provincial level. Years 2005, 2013, and 2018

Province	Gas			Electricity		
	2005	2013	2018	2005	2013	2018
CABA	955	893	681	232	264	269
Buenos Aires	1.071	1.268	991	193	256	251
Catamarca	790	809	698	143	236	281
Córdoba	944	1.110	854	133	188	284
Corrientes	n/d	n/d	n/d	183	247	202
Chaco	n/d	n/d	n/d	207	300	328
Chubut	3.557	5.043	3.963	174	226	234
Entre Ríos	917	1.082	906	169	228	214
Formosa	n/d	n/d	n/d	207	325	322
Jujuy	640	719	606	155	192	207
La Pampa	1.308	1.894	1.887	117	184	259
La Rioja	783	840	742	210	332	226
Mendoza	1.197	1.397	1.126	170	243	249
Misiones	n/d	n/d	n/d	163	244	345
Neuquén	3.075	2.762	3.714	182	207	152
Río Negro	2.924	2.571	3.197	148	189	357
Salta	734	684	627	167	229	383
San Juan	961	1.044	872	214	337	241
San Luis	1.142	1.480	1.210	170	246	267
Santa Cruz	6.569	7.507	7.288	160	216	301
Santa Fe	848	1.009	797	132	202	218
Santiago del Estero	528	522	460	169	262	316
Tucumán	628	629	567	167	243	141
Tierra del Fuego	7.967	8.659	7.073	222	242	182

Source: own elaboration based on ENARGAS and ADEERA. *Note:* The provinces of Corrientes, Chaco, Chubut, and Misiones do not have access to network gas service.

Main variables for the MEPI estimation in Section 4

MEPI estimation includes 6 variables from ENGHo. These variables are defined as follows:[13]

1. Type of fuel used for cooking: this variable is categorical and includes the following options: i) network gas, ii) bottled gas, iii) gas in cylinder, iv) electricity, v) kerosene/wood/coal, and vi) other. The paper transforms the variable into a binary where the household reports value 1 if it does not use network gas, bottled gas, gas in cylinder, or electricity, and reports 0 otherwise;

2. Access to electricity: this variable is binary, where it presents 1 if the household does not have a connection to the electricity network and 0 otherwise;

3. Access to a cell phone or landline: this variable is binary, where it presents 1 if the household does not have a cell phone or landline and 0 otherwise;

4. Access to refrigerator or freezer: this variable is binary, where it presents 1 if the household does not have a refrigerator or freezer and 0 otherwise;

5. Access to television or computer: this variable is binary, where it presents 1 if the household does not have a television or computer and 0 otherwise;

6. Share of energy expenditure in the total income: this variable represents the TPRI so if the household spends more than 10% of its total income on energy services it reports 1, otherwise 0.

[13] All the variables are defined from the perspective of the household's deprivations.

Table A3: Descriptive statistics for empirical analysis by year (2005, 2013, 2018)

Panel A: 2005								
Variable	Mean	SD	Min	p10	p50	p90	Max	N
[1] Type of fuel used for cooking	0.040	0.195	0	0	0	0	1	11212382
[2] Access to electricity	0.020	0.142	0	0	0	0	1	11212382
[3] Access to a cell phone or landline	0.249	0.432	0	0	0	1	1	11212382
[4] Access to refrigerator or freezer	0.070	0.254	0	0	0	0	1	11212382
[5] Access to television or computer	0.065	0.247	0	0	0	0	1	11212382
[6] GT_h^E/Y_h	0.121	0.327	0	0	0	1	1	11212382
Panel B: 2013								
Variable	Mean	SD	Min	p10	p50	p90	Max	N
[1] Type of fuel used for cooking	0.006	0.080	0	0	0	0	1	11197500
[2] Access to electricity	0.003	0.053	0	0	0	0	1	11197500
[3] Access to a cell phone or landline	0.032	0.176	0	0	0	0	1	11197500
[4] Access to refrigerator or freezer	0.027	0.163	0	0	0	0	1	11197500
[5] Access to television or computer	0.022	0.147	0	0	0	0	1	11197500
[6] GT_h^E/Y_h	0.019	0.136	0	0	0	0	1	11197500
Panel C: 2018								
Variable	Mean	SD	Min	p10	p50	p90	Max	N
[1] Type of fuel used for cooking	0.004	0.065	0	0	0	0	1	12642525
[2] Access to electricity	0.002	0.039	0	0	0	0	1	12642525
[3] Access to a cell phone or landline	0.020	0.141	0	0	0	0	1	12642525
[4] Access to refrigerator or freezer	0.020	0.140	0	0	0	0	1	12642525
[5] Access to television or computer	0.024	0.154	0	0	0	0	1	12642525
[6] GT_h^E/Y_h	0.138	0.345	0	0	0	1	1	12642525

Source: own elaboration based on ENGHo 2005, 2013, and 2018. *Note:* All values are weighted using the population expansion factor.

Table A4: Share of households with deprivation in the variables used for the MEPI estimation. Total country and provincial disaggregation. Year 2005

Province	[1]	[2]	[3]	[4]	[5]	[6]
Total country	4.0	2.0	24.9	7.0	6.5	12.1
CABA	0.0	0.0	4.7	2.0	1.9	1.9
Buenos Aires	0.8	0.6	18.6	4.3	3.9	12.0
Catamarca	11.7	1.2	50.9	10.0	8.5	10.5
Córdoba	1.3	2.0	22.3	4.8	4.4	12.9
Corrientes	21.5	6.9	43.1	19.6	20.7	23.7
Chaco	12.7	11.6	46.2	21.5	22.6	21.4
Chubut	1.6	0.4	16.2	4.5	3.5	6.6
Entre Ríos	7.9	6.6	35.1	12.9	15.7	12.3
Formosa	16.2	9.7	46.1	20.8	21.2	28.6
Jujuy	10.8	4.9	53.9	18.3	9.3	19.5
La Pampa	1.9	3.5	21.8	5.5	11.4	14.9
La Rioja	3.8	3.9	50.7	9.5	9.2	21.9
Mendoza	1.2	0.7	21.8	6.2	4.5	10.3
Misiones	29.3	7.1	50.5	16.6	21.8	16.9
Neuquén	0.9	0.9	27.4	4.5	6.5	18.3
Río Negro	2.4	0.8	28.4	7.1	6.7	11.3
Salta	13.1	4.6	52.8	19.6	11.8	14.5
San Juan	4.6	1.0	44.8	10.4	7.1	24.7
San Luis	2.3	3.0	39.6	8.8	7.1	10.3
Santa Cruz	0.3	0.1	12.5	4.1	4.3	5.6
Santa Fe	0.5	1.1	21.3	3.6	4.0	12.3
Santiago del Estero	27.5	14.8	63.6	18.4	19.0	12.7
Tucumán	10.9	2.0	47.0	13.6	9.8	11.1
Tierra del Fuego	0.0	0.0	7.6	2.2	0.9	2.8

Source: own elaboration based on ENGHo 2005. *Note:* The variables used to define each of the indicators are as follows: [1] Type of fuel used for cooking; [2] Access to electricity; [3] Access to a cell phone or landline; [4] Access to refrigerator or freezer; [5] Access to television or computer; [6] Share of energy expenditure in the total income. All values are weighted using the population expansion factor.

Table A5: Share of households with deprivation in the six variables used for MEPI estimation. Total country and provincial disaggregation. Year 2013

Province	[1]	[2]	[3]	[4]	[5]	[6]
Total country	0.6	0.3	3.2	2.7	2.2	1.9
CABA	0.1	0.1	0.9	1.5	0.9	0.3
Buenos Aires	0.4	0.2	2.3	2.4	1.9	1.6
Catamarca	1.0	1.2	3.1	5.6	1.9	1.3
Córdoba	0.1	1.1	2.5	1.2	2.7	4.2
Corrientes	2.2	0.3	6.0	7.6	5.9	2.2
Chaco	2.9	0.6	14.0	6.2	4.7	3.1
Chubut	0.3	0.3	2.7	1.4	2.7	3.6
Entre Ríos	1.0	0.4	3.7	4.3	3.4	3.1
Formosa	3.7	0.7	10.1	7.0	4.7	2.0
Jujuy	0.4	0.7	7.3	6.3	1.7	3.0
La Pampa	0.1	0.2	1.8	1.3	2.1	4.2
La Rioja	0.6	0.0	3.8	4.5	3.4	4.9
Mendoza	0.7	0.1	1.8	1.8	1.1	0.4
Misiones	2.2	0.1	7.7	3.9	5.3	3.1
Neuquén	0.1	0.1	0.8	1.1	1.1	4.1
Río Negro	0.0	0.0	4.8	5.1	3.7	3.1
Salta	3.5	0.3	6.1	9.4	2.6	2.4
San Juan	0.6	0.0	4.1	3.2	1.2	3.8
San Luis	0.4	0.1	3.3	1.6	1.3	1.0
Santa Cruz	0.0	0.0	1.3	3.5	0.6	1.2
Santa Fe	0.5	0.1	3.0	1.7	2.8	0.8
Santiago del Estero	1.9	0.9	7.8	2.1	2.9	2.5
Tucumán	1.3	0.0	7.2	4.4	1.5	1.5
Tierra del Fuego	0.4	0.0	0.8	2.1	0.7	2.8

Source: own elaboration based on ENGHo 2005. *Note:* The variables used to define each of the indicators are as follows: [1] Type of fuel used for cooking; [2] Access to electricity; [3] Access to a cell phone or landline; [4] Access to refrigerator or freezer; [5] Access to television or computer; [6] Share of energy expenditure in the total income. All values are weighted using the population expansion factor.

Table A6: Share of households with deprivation in the six variables used for MEPI estimation. Total country and provincial disaggregation. Year 2018

Province	[1]	[2]	[3]	[4]	[5]	[6]
Total country	0.4	0.2	2.0	2.0	2.4	13.8
CABA	0.3	0.0	0.5	1.5	2.5	3.4
Buenos Aires	0.1	0.2	2.1	2.1	1.8	14.2
Catamarca	0.7	0.1	2.6	1.8	3.3	16.0
Córdoba	0.3	0.2	0.9	1.3	3.0	17.3
Corrientes	1.6	0.0	2.7	2.5	2.6	11.6
Chaco	0.8	0.2	5.6	7.9	8.0	23.5
Chubut	0.1	0.5	2.0	1.4	2.1	19.1
Entre Ríos	0.1	0.0	3.5	1.4	4.8	18.6
Formosa	1.3	0.0	3.7	3.4	2.7	23.9
Jujuy	1.0	0.4	2.2	2.3	1.8	11.3
La Pampa	0.5	0.2	0.8	0.5	1.7	14.4
La Rioja	0.9	0.0	4.9	1.2	3.2	22.2
Mendoza	0.1	0.4	0.8	1.0	0.9	13.3
Misiones	2.5	0.0	2.9	2.7	7.0	15.3
Neuquén	0.0	0.2	0.6	1.1	2.5	8.8
Río Negro	4.0	0.0	4.1	1.0	2.1	10.0
Salta	1.5	0.5	3.9	2.7	3.1	17.6
San Juan	0.9	0.2	3.3	2.8	2.3	28.1
San Luis	0.2	0.0	0.4	0.7	3.1	15.4
Santa Cruz	0.0	0.0	0.2	0.4	1.2	11.7
Santa Fe	0.2	0.0	1.4	1.9	2.2	11.8
Santiago del Estero	0.9	0.3	4.4	2.7	2.1	17.3
Tucumán	0.4	0.0	3.9	2.5	1.5	14.5
Tierra del Fuego	2.4	0.0	0.0	0.9	1.7	3.9

Source: own elaboration based on ENGHo 2005. *Note:* The variables used to define each of the indicators are as follows: [1] Type of fuel used for cooking; [2] Access to electricity; [3] Access to a cell phone or landline; [4] Access to refrigerator or freezer; [5] Access to television or computer; [6] Share of energy expenditure in the total income. All values are weighted using the population expansion factor.

Table A7: Expenditure and consumption of natural gas by network and electricity by province in Argentina. Year 2005

	Expenditure ($ current)		Consumption (kep)		$/kep	
Province	Gas	Electricity	Gas	Electricity	Gas	Electricity
CABA	17	20	66	20	0.26	1.00
Buenos Aires	24	27	74	17	0.32	1.66
Catamarca	17	19	53	12	0.33	1.58
Córdoba	21	28	65	11	0.32	2.40
Chubut	17	33	246	15	0.07	2.19
Entre Ríos	14	24	63	15	0.22	1.66
Jujuy	16	30	44	13	0.37	2.22
La Pampa	22	29	90	10	0.25	2.92
La Rioja	21	33	54	18	0.38	1.85
Mendoza	21	21	83	15	0.25	1.42
Neuquén	20	29	213	16	0.09	1.83
Río Negro	19	26	202	13	0.09	2.04
Salta	18	25	51	14	0.36	1.74
San Juan	20	36	66	18	0.30	1.93
San Luis	29	22	79	15	0.36	1.50
Santa Cruz	20	33	454	14	0.04	2.40
Santa Fe	18	32	59	11	0.31	2.82
Santiago del Estero	13	23	36	15	0.35	1.60
Tucumán	14	22	43	14	0.33	1.53
Tierra del Fuego	22	29	551	19	0.04	1.52

Source: Own elaboration based on ENGHo 2018, ENARGAS, and ADEERA. *Note:* The provinces of Formosa, Chaco, Corrientes, and Misiones are not included in the analysis as they do not have access to piped natural gas. For a comparable measure, m3 and kWh are converted into kilograms of oil equivalent (kep) (1 m3 = 0.83 kep and 1 kWh = 0.086 kep). All values are weighted using the population expansion factor.

Table A8: Expenditure and consumption of natural gas by network and electricity by province in Argentina. Year 2013

	Expenditure ($ current)		Consumption (kep)		$/kep	
Province	Gas	Electricity	Gas	Electricity	Gas	Electricity
CABA	26	38	62	23	0.41	1.65
Buenos Aires	48	63	88	22	0.55	2.87
Catamarca	19	79	56	20	0.33	3.90
Córdoba	46	95	77	16	0.60	5.90
Chubut	37	136	349	19	0.11	7.01
Entre Ríos	33	98	75	20	0.44	5.00
Jujuy	25	98	50	16	0.51	5.97
La Pampa	32	104	131	16	0.25	6.58
La Rioja	23	99	58	29	0.40	3.48
Mendoza	37	58	97	21	0.38	2.76
Neuquén	39	78	191	18	0.20	4.40
Río Negro	32	62	178	16	0.18	3.83
Salta	25	86	47	20	0.53	4.36
San Juan	36	99	72	29	0.50	3.42
San Luis	43	62	102	21	0.42	2.94
Santa Cruz	39	92	519	19	0.08	4.96
Santa Fe	30	88	70	17	0.42	5.08
Santiago del Estero	18	78	36	23	0.50	3.45
Tucumán	25	76	44	21	0.57	3.62
Tierra del Fuego	42	104	599	21	0.07	4.99

Source: Own elaboration based on ENGHo 2018, ENARGAS, and ADEERA. *Note:* The provinces of Formosa, Chaco, Corrientes, and Misiones are not included in the analysis as they do not have access to piped natural gas. For a comparable measure, m3 and kWh are converted into kilograms of oil equivalent (kep) (1 m3 = 0.83 kep and 1 kWh = 0.086 kep). All values are weighted using the population expansion factor.

Table A9: Sensitivity analysis in TPRI's thresholds. Years 2005, 2013, and 2018

Threshold (%)	EP 2005 (%)	EP 2013 (%)	EP 2018 (%)
5.0	38.9	10.0	37.8
5.5	34.3	8.3	34.0
6.0	30.1	6.7	30.5
6.5	26.5	5.6	27.5
7.0	23.6	4.8	24.6
7.5	21.0	4.1	22.1
8.0	18.7	3.6	19.9
8.5	16.8	3.2	18.2
9.0	15.0	2.7	16.5
9.5	13.5	2.2	15.2
10.0	12.1	1.9	13.8
10.5	11.0	1.8	12.7
11.0	10.0	1.6	11.6
11.5	9.1	1.4	10.8
12.0	8.3	1.3	10.1
12.5	7.6	1.2	9.4
13.0	6.9	1.1	8.6
13.5	6.4	1.0	7.9
14.0	6.0	1.0	7.3
14.5	5.5	0.9	6.9
15.0	5.0	0.8	6.4

Source: own elaboration based on ENGHo 2005, 2013, and 2018. *Note:* All values are weighted using the population expansion factor.

Main variables for the probabilistic model estimation (subsection 6.3)

Probit estimation includes 23 variables from ENGHo. These variables are defined as follows:

1. Education level - Incomplete primary: this variable is binary, where it presents 1 if the head of household has completed primary school level and 0 otherwise;
2. Education level - Complete primary: this variable is binary, where it presents 1 if the head of household has completed primary school level and 0 otherwise;
3. Education level - Incomplete secondary: this variable is binary, where it presents 1 if the head of household has incomplete the secondary school level and 0 otherwise;
4. Education level - Complete secondary: this variable is binary, where it presents 1 if the head of household has complete the secondary school level and 0 otherwise;
5. Education level - Incomplete tertiary: this variable is binary, where it presents 1 if the head of household has incomplete the tertiary school level and 0 otherwise;
6. Education level - Complete tertiary: this variable is binary, where it presents 1 if the head of household has complete the tertiary school level and 0 otherwise;
7. Female head of household: this variable is binary, where it presents 1 if the head of household is female and 0 otherwise;
8. Age: this variable is nummerical;
9. Retired: this variable is binary, where it presents 1 if the head of household is retiree and 0 otherwise;
10. Married: this variable is binary, where it presents 1 if the head of household is married and 0 otherwise;
11. Type of housing: this variable is binary, where it presents 1 if the household is an apartment and 0 otherwise;
12. Type of family - Single-person: this variable is binary, where it presents 1 if the family is single-person and 0 otherwise;
13. Type of family - Nuclear family without children: this variable is binary, where it presents 1 if the family is nuclear without children and 0 otherwise;

14. Type of family - Nuclear family with children: this variable is binary, where it presents 1 if the family is nuclear with children and 0 otherwise;

15. Type of family - Extended family: this variable is binary, where it presents 1 if the family is extended and 0 otherwise;

16. Access to public water network: this variable is binary, where it presents 1 if the household has access to public water network and 0 otherwise;

17. Access to sewer system: this variable is binary, where it presents 1 if the household has access to sewer system and 0 otherwise;

18. Region - Metropolitana: this variable is binary, where it presents 1 if the household live in the Metropolitana Region and 0 otherwise;

19. Region - Pampeana: this variable is binary, where it presents 1 if the household live in the Pampeana Region and 0 otherwise;

20. Region - Northwest: this variable is binary, where it presents 1 if the household live in the Northwest Region and 0 otherwise;

21. Region - Northeast: this variable is binary, where it presents 1 if the household live in the Northeast Region and 0 otherwise;

22. Region - Cuyo: this variable is binary, where it presents 1 if the household live in the Cuyo Region and 0 otherwise;

23. Region - Patagonia: this variable is binary, where it presents 1 if the household live in the Patagónica Region and 0 otherwise.

Table A10: Descriptive statistics for probabilitic model

Descriptive Statistics								
Variable	Mean	SD	Min	p10	p50	p90	Max	N
[1] Education level - Incomplete primary	0.083	0.276	0	0	0	0	1	12642525
[2] Education level - Complete primary	0.218	0.413	0	0	0	1	1	12642525
[3] Education level - Incomplete secondary	0.158	0.365	0	0	0	1	1	12642525
[4] Education level - Complete secondary	0.227	0.419	0	0	0	1	1	12642525
[5] Education level - Incomplete tertiary	0.110	0.312	0	0	0	1	1	12642525
[6] Education level - Complete tertiary	0.192	0.394	0	0	0	1	1	12642525
[7] Female head of household	0.428	0.495	0	0	0	1	1	12642525
[8] Age	50.536	16.477	16	30	49	73	98	12642525
[9] Retired	0.280	0.449	0	0	0	1	1	12642525
[10] Married	0.606	0.489	0	0	1	1	1	12642525
[11] Type of housing	0.212	0.409	0	0	0	1	1	12642525
[12] Type of family - Single-person	0.169	0.375	0	0	0	1	1	12642525
[13] Type of family - Nuclear family without children	0.144	0.351	0	0	0	1	1	12642525
[14] Type of family - Nuclear family with children	0.499	0.500	0	0	0	1	1	12642525
[15] Type of family - Extended family	0.188	0.390	0	0	0	1	1	12642525
[16] Access to public water network	0.907	0.290	0	1	1	1	1	12642525
[17] Access to sewer system	0.676	0.468	0	0	1	1	1	12642525
[18] Region - Metropolitana	0.379	0.485	0	0	0	1	1	12642525
[19] Region - Pampeana	0.334	0.472	0	0	0	1	1	12642525
[20] Region - Northwest	0.092	0.289	0	0	0	0	1	12642525
[21] Region - Northeast	0.074	0.261	0	0	0	0	1	12642525
[22] Region - Cuyo	0.062	0.241	0	0	0	0	1	12642525
[23] Region - Patagonia	0.058	0.235	0	0	0	0	1	12642525

Source: own elaboration based on ENGHo 2018. *Note:* All values are weighted using the population expansion factor.

Table A11: Descriptive statistics of income households for variables of probabilitic model

				Total household income				
Variable	Mean	SD	Min	p10	p50	p90	Max	N
Education level - Incomplete primary	20394	15316	0	7029	17187	39000	490500	1051048
Education level - Complete primary	24032	16875	500	7741	19705	45000	216167	2761690
Education level - Incomplete secondary	27930	50712	0	8300	21623	49217	1129333	2001587
Education level - Complete secondary	32341	32908	0	10716	26833	57800	1100000	2874572
Education level - Incomplete tertiary	32920	33332	0	8000	26000	63250	2461500	1384774
Education level - Complete tertiary	50078	38226	0	16189	40517	93000	506154	2427606
Female head of household	27463	22533	0	7867	21694	52765	384297	5409830
Man head of household	35621	41757	0	10083	27400	66380	2461500	7232695
Retired	29835	43354	1667	8500	22109	55522	2461500	3543217
Not Retired	33024	31236	0	8900	26000	62183	1100000	9098608
Married	37594	40876	0	12400	29250	69100	2461500	7658349
Not Married	23736	20952	0	7000	18653	45283	1100000	4984176
Apartment	35248	29890	0	9500	28800	66667	707833	2677681
Not Apartment	31293	36311	0	8598	24167	58750	2461500	9964844
Type of family - Single-person	20291	23065	0	6000	15000	40000	1100000	2137660
Type of family - Nuclear family without children	36590	61143	0	12570	26083	65000	1129333	1823111
Type of family - Nuclear family with children	34193	28920	0	9921	26793	65000	707833	6310617
Type of family - Extended family	33886	28791	0	11780	28501	59200	2461500	2371137
Access to public water network	32637	36203	0	8894	25000	61500	2461500	11471142
Not access to public water network	27171	20610	0	7583	22943	50400	372902	1171383
Access to sewer system	35523	39345	0	9818	27508	66667	1129333	8542828
Not access to sewer system	25061	22283	0	7400	20275	47033	2461500	4099697
Region - Metropolitana	35194	33985	0	9071	27583	141378	1022578	4797669
Region - Pampeana	31593	41377	0	8800	24100	58717	1129333	4228997
Region - Northwest	26852	28699	0	8463	21875	49967	2461500	1165960
Region - Northeast	21762	18846	0	7000	17469	40567	495333	931176
Region - Cuyo	28952	22319	1667	9290	23300	54167	225333	780368
Region - Patagonia	40071	34357	0	10483	31417	77667	686797	738355

Source: own elaboration based on ENGHo 2018. *Note:* All values are weighted using the population expansion factor.