SPLIT INCENTIVES: A PRELIMINARY INVESTIGATION INTO CASE OF TÜRKİYE

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ABSTRACT

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The split incentive problem represents a significant barrier to energy efficiency in the residential sector, particularly affecting the dynamics between property owners and tenants. This study investigates the presence of split incentives in the Turkish residential market, exploring how the misalignment between property owners and tenants contributes to divergent energy demand patterns. By employing household-level data from the Turkish Statistical Office's Household Expenditure Surveys (2002-2019), we analyze energy expenditures and consumption across different tenure statuses. The findings document preliminary evidence of split incentives in the Turkish rental market, with tenants generally exhibiting higher monthly energy expenditures compared to homeowners. Notable energy efficiency gaps are observed between tenants and homeowners when considering differing house types and family sizes. The results highlight the need for targeted policy measures to align incentives between homeowners and tenants, with the ultimate goal of reducing energy inefficiencies in the residential sector.

ÖZET

TEŞVİK EŞİTSİZLİĞİ: TÜRKIYE BAĞLAMI ÜZERINE BIR ÖN INCELEME

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Anahtar Kelimeler: teşvik eşitsizliği, enerji verimliliği, konut piyasası, mülkiyet

Teşvik eşitsizliği sorunu, özellikle ev sahipleri ve kiracılar arasındaki dinamikleri etkileyerek konut sektöründe enerji verimliliğinin sağlanmasının önünde önemli bir engel teşkil etmektedir. Bu çalışma, Türkiye'deki konut piyasasında teşvik eşitsizliklerinin varlığını araştırmakta ve ev sahipleri ile kiracılar arasındaki potansiyel uyumsuzlukların farklı enerji kullanım örüntülerine nasıl katkıda bulunduğunu incelemektedir. Bu amaçla, Türkiye İstatistik Kurumu'nun 2002-2019 yıllarını kapsayan hanehalkı düzeyindeki verileri kullanılarak, farklı mülkiyet statülerine göre enerji harcamaları ve tüketimi analiz edilmiştir. Bulgular, genellikle kiracıların ev sahiplerine kıyasla daha yüksek aylık enerji harcamaları sergilediğini ortaya koymaktadır. Ek olarak, farklı ev mimarileri ve aile büyüklüklerine göre yapılan değerlendirmelerde kiracılar ve ev sahipleri arasında kayda değer farklılıklar gözlenmektedir. Sonuçlar, konut sektöründeki enerji verimsizliğini azaltma hedefiyle, ev sahipleri ve kiracılar arasındaki teşvikleri uyumlu hale getirmek için tasarlanmış odaklı politika tasarılarına yönelik ihtiyacın altını çizmektedir.

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1. INTRODUCTION

The global imperative to combat climate change and regulate energy consumption, together with the need for effective energy efficiency policies, underscores the need for a in-depth examination of energy consumption patterns and the market forces shaping them. Energy inefficiency within the residential sector remains a widespread problem, contributing significantly to both economic burdens and environmental impacts. Despite the substantial potential for energy efficiency improvements identified by numerous studies, an energy efficiency gap remains. This problem is largely due to market barriers and failures, including principal-agent (PA) problems, which limit the adoption of energy-efficient technologies and practices.

These market barriers and failures to energy efficiency are multifaceted. They include the low prioritization of energy costs, difficulties in accessing capital for energy-efficient investments, and the incomplete nature of energy-efficiency markets. Such inefficiencies are particularly pronounced in the landlord/renter dichotomy within the tenant-occupied dwellings, where the dynamics of property tenure significantly influence energy consumption behaviors and technology adoption rates. The different adoption and use of energy-efficient technologies between these tenure types can be attributed to several underlying factors. These include varying levels of decision-making authority, financial constraints, and differing perceptions of the long-term benefits associated with energy efficiency investments.

In owner-occupied homes, homeowners often prioritize making energy-efficient investments due to their enduring benefits. These investments not only promise reduced utility costs but also hold the potential to increase the overall value of the property over time. Conversely, in tenant-occupied dwellings, incentives between landlords and tenants often diverges. Property owners may be reluctant to invest in energy efficiency if they do not directly benefit from energy savings, while tenants lack the incentive to invest in property upgrades due to their temporary occupancy. This misalignment is an example of the principal-agent problem, commonly referred to as split incentives.

The split incentive problem focuses on how the tenure status of a dwelling affects energy efficiency upgrades, which ultimately translates into discrepancies in energy consumption and expenditure between property owners and tenants. The problem arises when the interests of property owners (principals) and tenants (agents) are misaligned with respect to energy efficiency investments. Property owners, who typically bear the up-front costs of installing energy-efficient technologies, often lack sufficient incentives to make such investments, especially when tenants reap the benefits through reduced energy bills. Conversely, tenants who are responsible for energy consumption may lack the authority or motivation to invest in property upgrades that would enhance energy efficiency.

This misalignment creates a sub-optimal equilibrium where neither party is incentivized to undertake improvements, leading to persistently higher energy consumption levels in tenant-occupied dwellings compared to owner-occupied ones. The resulting underinvestment in energy efficiency leads to higher energy consumption and perpetuates inefficiency in the housing market. The following diagram (Figure 1), which is an extension of de T'Serclaes (2007) and Gillingham, Harding, and Rapson (2012), introduces a conceptual framework and clarifies the possible scenarios in which incentives between the parties are misaligned.

Figure 1.1 A diagram of four possible scenarios of split incentives

		Homeowners	
		Occupy	Rent
Tenants	Pay	(Case 1) **no principal - agent problem** no split incentives	(Case 2) **efficiency problem** H: avoids energy-efficiency upgrades T: optimal consumption; less insulation and higher energy expenditures
	Do not pay	(Case 3) **usage and efficiency problem** H: avoids energy-efficiency upgrades T: minimal effort to conserve	(Case 4) **usage problem** H: optimal insulation & efficient appliances T: minimal effort to conserve

(Case 1) No PA problem: Both parties are incentivized to conserve energy in an owner-occupied dwelling where the tenant pays for energy (for example, a single-family home with a rented basement). Because he is responsible for his utility bills, the tenant is motivated to use energy-efficient appliances and conserve energy, resulting in cost savings and optimal energy use.

(Case 2) Efficiency problem: In this scenario, the tenant pays for energy but cannot influence the landlord's decisions on energy efficiency. The landlord has little incentive to invest in upgrades such as insulation or modern appliances because he does not benefit from the energy savings. This results in higher energy costs for the tenant and lower overall energy efficiency.

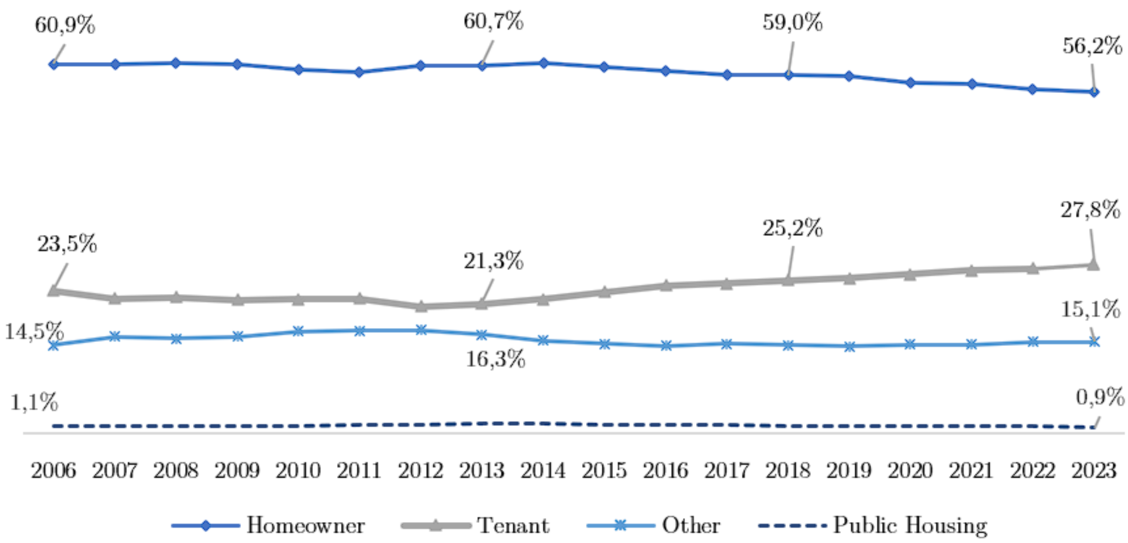
(Case 3) Usage and efficiency problem: Here, the tenant does not pay for their energy use, leading to less motivation to conserve energy or invest in energy-efficient appliances. For example, in a townhouse complex with shared heating costs, homeowners are less inclined to conserve energy or invest in efficiency, resulting in higher energy consumption and lower overall efficiency.

(Case 4) Usage problem: In this case, the tenant does not pay for some portion of their energy use, such as heating or cooling. This lack of financial responsibility leads to excessive energy use and neglect of energy-saving practices. For example, a tenant may leave the air conditioner on all the time, knowing the landlord covers the costs. This principal-agent problem leads to higher energy consumption and inefficiency.

In our study's focus, Türkiye, rental agreements are governed by the Turkish Code of Obligations (TBK) No. 6098. This legislation covers lease contracts for both residential and commercial properties, outlining the rights and responsibilities of tenants and property owners. According to the TBK, unless explicitly stated otherwise, tenants are the responsible parties for routine expenses such as electricity, water, and heating (Turkish Code of Obligations (2011)). Additionally, communal expenses like apartment maintenance fees are also covered by the tenants. Occasionally, rental contracts may include provisions for utilities and expenses. In such cases, costs such as electricity, water, and natural gas are included in the rent, and tenants do not make separate payments for these services. This type of rental arrangement is typically found in student dormitories, apart-hotels, and short-term rental properties. Although there are no official figures to statistically support this argument, anecdotal evidence suggests that such rental arrangements are not the norm in the Turkish residential market. Therefore, any investigation into potential split incentives within the Turkish residential context would likely concentrate on (Case 2).

The case of Türkiye presents a compelling context for examining the effects of split incentives on residential energy consumption. Türkiye's residential sector is characterized by a relatively low homeownership rate compared to global averages. According to Turkish Statistical Office (TURKSTAT), the homeownership rate has been steadily declining from 60.9% in 2006 to 56.2% in 2023, with the trend accelerating in recent years (Figure 2). Correspondingly, an increasing portion of the population is becoming renters, with renters accounting for 27.8% of the residential market as of 2023. This implies that more than a quarter of the residential market participants are tenants.

Figure 1.2 Homeownership statistics of residential properties in Türkiye (2006-2023)



Source: TURKSTAT

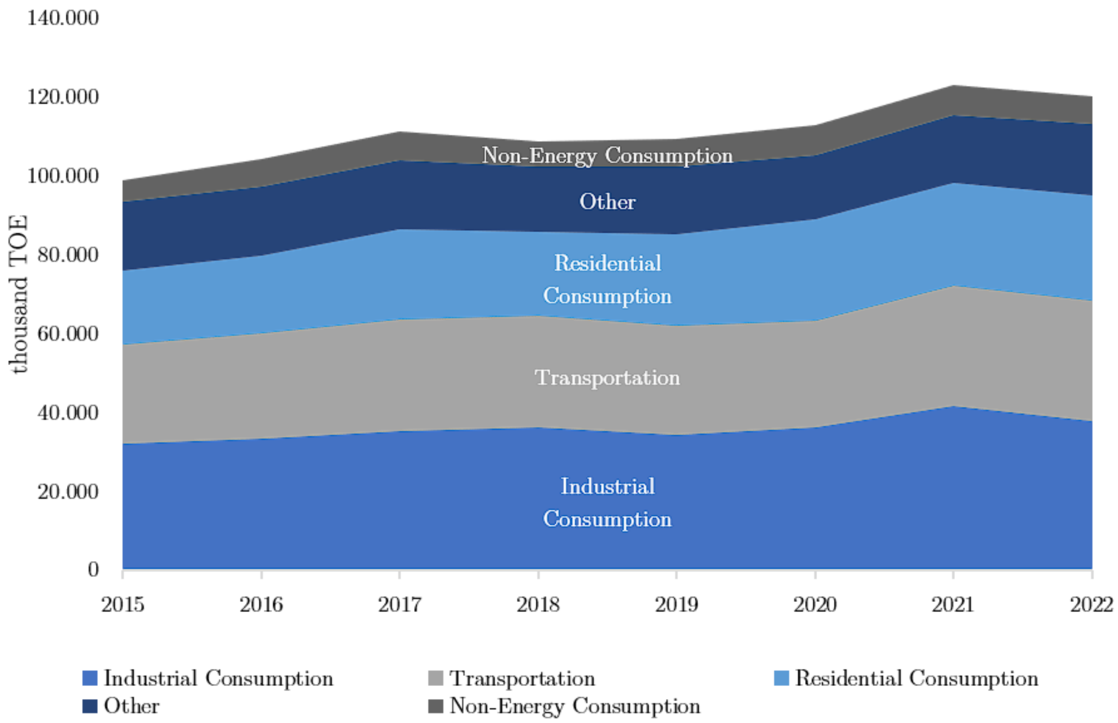
As shown in Table 1.1, Türkiye lags behind its emerging market (EM) counterparts regarding homeownership rates. In 2023, Türkiye's homeownership rate of 56.2% was notably lower compared to global averages, such as the European Union (EU) average (69.2%), the G20 average (70.0%), and other emerging market economies. Several factors may be at play contribute to this disparity. Lower per capita income levels and high property prices relative to disposable income limit the ability of individuals to purchase homes. In addition, rapid urbanization and high population growth rates may be outpacing the expansion of affordable housing stock. Apart from these, changing macroeconomic policy practices directly stress the market environment, further exacerbating the homeownership outlook. Whatever the pioneering reason, the characteristics of the Turkish residential market underscore the importance of a closer examination, as the potential extent of split incentives is intrinsically linked to the dynamics of the rental market.

Table 1.1 Homeownership rates by country and region

Country & Region	China	Russia	India	EM	Indonesia	Mexico	Brazil	Euro Area	S. Africa	EU	G20	Türkiye
Homeownership Rate (%)	89.7	89.0	86.6	86.5	84.0	76.4	72.5	70.0	69.7	69.2	65.7	56.2
Reference Date	2018	2018	2011	varies	2019	2010	2019	2023	2021	2023	varies	2023

Investigating the impact of split incentives is also critical from an economic policy perspective. Energy inefficiency in the residential sector translates into increased energy consumption, higher energy bills for individuals, and a greater national energy burden. Residential energy consumption accounts for a significant share of Türkiye's total energy consumption. As a net energy importer developing country, Türkiye is experiencing sustained growth in overall energy consumption, as illustrated in Figure 3. Accordingly, the total energy consumption in 2022 stood at 120,200 thousand TOE, with 26,700 thousand TOE stemming from residential consumption. Notably, the share of residential energy consumption has been steadily increasing, from 19% in 2015 to 22% in 2022, and is expected to grow further.

Figure 1.3 Total energy consumption breakdown of Türkiye (2015-2022)



Source: Ministry of Energy and Natural Resources National Energy Balance Tables, author's calculations.

This study represents the first attempt to conduct a preliminary investigation into the potential presence of a split incentive problem in Türkiye's emerging market context. Characterized by a low homeownership rate below global peers coupled with a growing proportion of renters contributing to residential energy consumption, Türkiye's context provides an ideal environment for studying split incentives. To this end, we leverage a comprehensive dataset from the Turkish Statistical Office's annual Household Expenditure Surveys, spanning the years 2002 to 2019. The dataset encompasses detailed information on monthly spending on a range of items, household demographics, housing characteristics, and ownership of electronic amenities, with a total sample size of 71,320 households.

Our empirical approach examines household energy efficiency by analyzing energy consumption and expenditures, with a particular focus on the influence of tenure status while controlling for building construction period and age. We systematically account for a wide range of observable dwelling characteristics and household demographics, including temporal climate variations and regional effects, to identify the multifaceted factors that shape residential energy demand in Turkey.

The investigation of the interplay between home ownership status and energy expenditure and consumption in the Turkish residential setting revealed preliminary evidence regarding the presence of split incentives. Accordingly, tenants typically have higher monthly energy expenditures than property owners, although these differences are not reflected in energy consumption figures when comprehensive controls are applied. Additionally, notable disparities emerged between tenants and homeowners based on varying house types, family sizes, and different heating methods.

2. LITERATURE REVIEW

The residential energy misalignment between homeowners and tenants has been examined across various geographic settings. These studies vary in their empirical frameworks, time spans, and levels of data aggregation, as there is no one-size-fits-all method for investigating split incentives. Studies from North America paint a clear picture regarding the presence of split incentives. Levinson and Niemann (2004) investigate energy consumption patterns in utility-included apartments across the U.S. with a special focus on California. They find that more than one-quarter of U.S. apartment residents live in such rental settings, impacting both energy usage and rent pricing. Using household-level survey data and a natural experiment approach, the authors note that tenants in utility-included apartments tend to use more energy, particularly by maintaining warmer temperatures in winter when they are away from home. Utility-included apartments are found to be prevalent due to property owners' cost-saving measures and tenant preferences, where bundling energy costs into rent reduces administrative expenses, although the rental premium often falls short of covering actual energy usage, while tenants typically consume more energy, especially heating.

Gillingham, Harding, and Rapson (2012) extend this study by developing a theoretical framework. They highlight that properties, where property owners cover utility costs, tend to exhibit higher energy consumption, particularly in heating and cooling. In these scenarios, tenants show reduced inclination towards energy conservation measures such as thermostat adjustments and insulation investments. Conversely, owner-occupied residences where occupants are responsible for utility payments demonstrate greater adoption of energy-efficient practices, including a 20% higher likelihood of having adequate attic insulation and a 13% higher likelihood of having well-insulated exterior walls.

Melvin (2018) examines property owners' reluctance to invest in energy-efficient measures using data from the 2009 Residential Energy Consumption Survey (RECS). The study reveals significant underinvestment by owners who do not pay for utilities, leading to approximately 4% higher spending on space heating, 2.8% more on air conditioning, and 0.6% more on water heating by tenants. This results in a 2.7% increase in overall energy consumption, notably affecting natural gas (3.9% increase) and electricity (1.2% increase) usage. The study also indicates a slight environmental impact, accounting for about 0.1% of total U.S. carbon emissions.

Murtishaw and Sathaye (2006) study the principal-agent problem in the U.S. residential sector, focusing on energy use in refrigeration, water heating, space heating, and lighting, which comprised about 35% of total residential sector energy consumption in 2003. They highlight potential energy savings if principal-agent barriers were addressed, particularly for refrigerators and water heaters, noting that price signals and information programs alone cannot effectively promote energy conservation due to limited user control over efficiency and partial insulation from energy costs. Best, Burke, and Nishitateno (2021) analyze factors influencing renters' electricity consumption in the US and find tenants consume about 9% more electricity than non-renters, even after accounting for location, socioeconomic factors, and appliance quantities. Further, renters are more inclined to use electric space and water heaters and show behavioral differences, such as extended weekday use of the main television.

Davis (2011) investigates the slower adoption of energy-efficient investments in the U.S., focusing particularly on the prevalence of energy-efficient appliances among renters compared to homeowners. Drawing insights from household-level data sourced from the American Housing Survey, Davis demonstrates that renters are significantly less likely to possess ENERGY STAR-rated appliances like refrigerators, washing machines, and HVAC systems. Souza (2018) focus on the same question and find that homeowners are notably more likely than renters to have ENERGY STAR-rated appliances. Accordingly, rented homes exhibit substantial deficiencies in ENERGY STAR-rated appliances, with gaps widening over time compared to earlier estimates. For example, while Davis (2011) found a gap of -6.7% for refrigerators, Souza reports a more pronounced gap of approximately -15%. Additionally, rental units show a lower prevalence of ENERGY STAR central air conditioners, dishwashers, clothes washers, refrigerators, and heating equipment. In his subsequent work, Davis (2023) expands on this research and reaffirms that renters are notably less likely to use energy-efficient electric appliances, including heating, hot water systems, stoves, and dryers, compared to homeowners and that this discrepancy persists across different regions and remains significant.

Finally, for the U.S. context, Myers (2020) uses American Housing Survey data (1985-2009) to explore how asymmetric information in rental markets affects energy efficiency. The study finds that tenants' limited awareness of energy costs leads to higher energy expenditures. This information gap also discourages property owners from investing sufficiently in energy efficiency. The author underlines that addressing this asymmetry could cut energy consumption by 1-3%, an effect equivalent to a short-term electricity price increase of 11-20%. The study further documents that property owners who cover energy costs are more likely to invest in measures that reduce energy costs.

Research in Europe presents a more nuanced picture and suggests the impact of contextual differences on energy consumption behavior. Charlier (2015) investigates French households and finds that split incentives significantly hinder energy efficiency investments by tenants, who face higher energy costs due to inefficient building characteristics. Accordingly, only 25% of households making energy-saving investments are renters. Despite substantial policy efforts such as tax credits amounting to €7.8 billion from 2005 to 2008, it is argued that the effectiveness of these measures in mitigating the split incentive problem has been limited.

Nie et al. (2020) examine the impact of split incentives on energy-saving measures in Western European households, analyzing data from 1,248 households in the Netherlands, Germany, and Belgium. They find that homeowners are 16.08% more likely to adopt energy-efficient technologies and 4.28% more likely to implement behavioral measures. Specifically, homeowners show higher adoption rates for technical measures such as thermal insulation (25.6%), solar panels (10.2%), efficient boilers (13.5%), and LEDs (15%), while differences in behavioral practices are smaller (ranging from 1.5% to 5.9%).

Krishnamurthy, Kiran, and Kristrom (2015) analyze the owner-renter gap in energy-efficient technology adoption across 11 OECD countries. They find owners are likelier than renters to have energy-efficient appliances, better insulation, and heating thermostats. Specifically, owners are 45% more likely to use energy-efficient appliances and 50% more likely to use energy-efficient bulbs. The study also highlights smaller but significant effects for insulation (9.5% for roof/walls, 12.4% for windows) and heating thermostats (9.8%), with minimal impact for technologies such as solar panels (2.5%). Petrov and Ryan (2021), on the other hand, studied the landlord-tenant problem and energy efficiency in Ireland's rental market using data from 585,578 properties. They find that rental properties generally have lower energy efficiency than non-rental properties, especially in areas with limited rental availability.

Rehdanz (2007) investigates household expenditures on space heating and hot water in Germany using panel data spanning 1998 to 2003. The study reveals that renters spend more on heating than homeowners, attributed to homeowners' greater investment in energy-efficient systems. Property owners, facing stricter rent controls and bearing improvement costs, have less incentive to upgrade rental properties. Meier and Rehdanz (2010) extend this analysis to Great Britain using 15 years of panel data covering on more than 5,000 households. In contrast, they find that homeowners generally incur higher heating costs than renters, driven by differences in housing types. The study integrates weather data to assess the impact of climate on heating expenditures, highlighting variables such as household size, age, and heating degree days.

Finally, Maruejols and Young (2011) analyze the impact of split incentives on energy efficiency in Canadian multi-family dwellings and find that households not responsible for heating bills maintain indoor temperatures approximately 1° C warmer during the day and are less likely to adjust thermostats when the dwelling is unoccupied, resulting in higher energy consumption. While property owners covering utility costs tend to plan more energy-saving renovations, the actual impact is not statistically significant.

However, not all studies document conclusive evidence regarding the presence of split incentives. Aydın, Eicholtz, and Holtermans (2019) examine a comprehensive dataset covering nearly three million dwellings in the Netherlands over six years. Contrary to prevailing findings, their analysis of dwellings that experienced a change in tenure status, i.e., transitioning from rental to owner-occupied status, revealed that energy efficiency investments do not differ significantly between renters and homeowners. Their results indicate that factors beyond the financial aspects of the transaction, such as government regulations or tenant preferences for energy-efficient features, might be more influential in certain contexts.

Similarly, Wood, Ong, and McMurray (2012) examine the split-incentive issue in the Australian private rental housing market using 2006 data from the HILDA survey. Contrary to findings in Europe and North America, their study finds no significant evidence supporting the split-incentive hypothesis in Australia. They attribute this to differences in housing policy, including the absence of rent controls, strong tenure legislation, and an unregulated rental market incentivized by tax benefits.

In a more recent study, Singhal et al. (2023) investigate the problem from the perspective of thermal efficiency investments in the German rental housing market. Using data from Germany's largest online housing platform, they find only a small, economically insignificant difference in energy performance scores between owner-occupied and rental apartments.

Despite extensive research in developed countries, the extent of this problem in emerging markets remains largely unexplored, and empirical evidence is scarce. Sandoval and Hancevic (2023) is the only study focusing on an emerging economy context. Using data from Mexican households, they find that renters in Mexico have lower insulation and use less energy-efficient equipment, leading to higher utility bills compared to homeowners. Furthermore, renters demonstrate lesser awareness and participation in government-sponsored energy-saving initiatives. Our objective is to make a contribution to this body of work through an exclusive focus on the residential market of another developing economy, i.e., Türkiye.

3. DATA

In our study of split incentives, we employ an extensive household-level dataset compiled by the Turkish Statistical Office. This dataset is derived from the annual Household Expenditure Surveys, which encompass a representative sample of over 9,000 households each year. Our analysis concentrates on data collected from 2002 to 2019. These surveys offer a detailed overview of household energy consumption and expenditures.

Specifically, the analysis categorizes energy demand into several key components: monthly energy expenditures, monthly non-energy expenditures, monthly non-electricity energy expenditures, and costs related to maintenance, gas, coal and wood, LPG, and heating oil. Additionally, the surveys gather extensive demographic information about the households, including annual income, household size, employment status, the number of working household members, average working hours per week, the number of children under the ages of 15 and 20, the number of elderly residents, the number of female household members, the education level of the household head, and the length of stay in the current residence.

A particularly distinctive aspect of the dataset is its detailed documentation of housing characteristics. Respondents report comprehensive information about their dwellings, including the size (m^2), house type (attached or apartment), the number of rooms, and the number of toilets, kitchens, and bathrooms. Additionally, details are provided on the heating method, the primary and secondary energy sources used for heating, the availability of natural gas, and the presence of central heating mechanisms and hot water systems.[1] Beyond these, the dataset also encompasses information on household ownership of various electronic amenities, such as refrigerators, freezers, dishwashers, washing machines, computers, and air conditioners.[2]

[1] The survey does not explicitly indicate whether heating costs are included in rental contracts, making it difficult to effectively distinguish households with utility-included rental contracts from those without.

[2] The survey omits notable details on dwelling thermal performance, including insulation levels (roof, wall, window, etc.), age of the heating system, house façade characteristics, and energy efficiency labels of appliances, all of which are pivotal for accurately assessing energy consumption patterns.

In order to refine the sample, several exclusions were implemented. Households primarily using wood as their energy source were excluded from the analysis because this particular item can be obtained without any expenditure, rendering the expenditure data regarding it unreliable. Households utilizing electrical equipment for heating were also excluded from the analysis. This decision was made because it is impractical to disentangle daily electricity consumption from that used for heating purposes. These households constituted approximately 3% of the total observations. Nonetheless, these observations were reintegrated into the sample during the robustness tests. In addition, the expenditure figures were converted to actual consumption based on the price of each energy source in different years and the energy content of those resources. The resulting figures were then used to calculate the household's monthly energy consumption (kWh). Finally, we omitted households reporting zero energy or electricity consumption, as well as extreme outliers according to total and individual energy source consumption. Through this careful curation, we arrived at a sample of 71,320 households, of which 28,7% are tenants.

The descriptive statistics provide notable insights into the energy expenditure patterns among homeowners and tenants.[3] A preliminary analysis of energy expenditure reveals that homeowners generally incur higher energy costs than tenants. In 2019, the average monthly energy expenditure for homeowners was approximately 198 TL, while tenants spent around 191 TL. This pattern holds across the entire sample as well, although the difference is less pronounced. Similarly, when examining monthly energy consumption measured in kilowatt-hours (kWh), homeowners consistently exhibit higher consumption levels than tenants. Notably, there is no significant difference between homeowners and renters regarding monthly electricity expenditures. Not surprisingly, homeowners typically have higher annual incomes than renters, both in recent observations and across the entire sample. This financial disparity is reflected in various categories of household expenditures, including monthly energy expenditures, non-energy expenditures, maintenance costs, and spending on different energy items.

In terms of dwelling characteristics, the results show marked differences between homeowners and tenants. For the entire sample, 72% of homeowners live in apartments, and 28% live in detached houses. Of the tenants, 87% live in apartments, and only 13% of tenants live in detached houses. For property owners, this gap decreases notably in favor of detached housing preferences in the terminal year of observations, wherein 43% of property owners live in detached dwellings, indicating a growing preference for detached houses among homeowners.

[3] Table A.1 of the Appendix provides a comprehensive summary of key descriptive statistics for the entire sample as well as the most recent year of observation, with a particular focus on home ownership status.

Homeownership status does not seem to significantly impact the adoption rates of different heating methods. For the entire sample, individual boilers are the most common heating method for homeowners and tenants, followed by stoves and central heating systems. In the most recent year of observations, the difference is more pronounced, with 58% of tenants using individual boilers for heating, compared to 50% of homeowners. This suggests that while individual boilers remain predominant, their prevalence has increased. In line with the heating types of houses, natural gas stands as the predominant energy source, followed by coal. These descriptive results highlight significant differences in the primary energy sources utilized by homeowners and tenants, underscoring the necessity for a sub-analysis to examine these systematic differences in energy consumption and expenditure.

Natural gas availability also differs significantly between homeowners and tenants. Recent data indicate that tenants have higher rates of natural gas availability, a trend consistent across the entire dataset. This discrepancy may be attributed to the higher proportion of homeowners living in detached houses, where natural gas infrastructure is less prevalent. Other housing features, such as the presence of central heating, water heating methods, kitchen energy sources, and floor types, also show significant differences between the two groups.

When examining household demographics, homeowners generally have larger houses with more rooms compared to those occupied by tenants. Homeowners tend to have larger families, although tenants report having more children on average. Conversely, homeowners have a higher number of elderly members in their households, likely reflecting the age at which individuals typically acquire the financial means to purchase a home in Türkiye. These demographic differences are significant across both recent and historical data. Additionally, tenants report higher levels of educational attainment compared to homeowners.

Employment status further differentiates homeowners and tenants. While 79% of tenants report being currently employed, only 60% of homeowners are employed. This disparity extends to the average number of employed household members and their working hours, which directly affects the amount of time spent at home and ultimately shapes household energy consumption patterns. Finally, homeowners tend to have greater availability of energy-consuming appliances, including refrigerators, freezers, dishwashers, microwaves, washing machines, computers, and air conditioners. This greater access to electrical equipment further contributes to the higher energy consumption observed among homeowners. Given the potential influence of these factors on observed differences in energy consumption patterns of property owners and tenants, we have explicitly accounted for them in our specifications.

4. EMPIRICAL STRATEGY

In accordance with the objective of the study, we examine the relationship between homeownership status and the energy efficiency of residential buildings. Although an ideal experimental design could isolate the split incentive effect by observing occupants transitioning from renting to owning while keeping other factors constant, in our setting, practical constraints make such experiments impractical.[4] Instead, we leverage cross-sectional data to approximate this scenario and investigate the impact of tenure status on household energy demand by using household energy consumption and spending as proxies and proceed with the following cross-sectional ordinary least squares (OLS) analysis:

$$\begin{aligned}\ln(y_i) = \alpha + \beta \text{ownership}_i + \gamma \text{constructionperiod (year)}_i \\ + \delta \text{housing}_i + \eta \text{HH}_i + \phi \text{time}_i + \xi \text{region}_i + \epsilon_i\end{aligned}$$

Energy efficiency can be viewed as a function of both housing and household characteristics. Here, $\ln(y_i)$ represents the outcome of interest and can be the logarithm of the household's monthly energy expenditure, monthly non-electricity expenditure, monthly energy consumption, and monthly non-electricity energy consumption, depending on the specification.[5] The variable $ownership_i$ is the primary variable of interest indicating whether the respondent is a property owner or a tenant, and its coefficient captures the causal effect of tenure status on energy efficiency, approximated by energy spending and consumption.

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[4] The cross-sectional nature of the design does not account for individual heterogeneity, meaning that we cannot isolate the effects of tenants who subsequently become homeowners. In essence, the absence of panel data constrains the ability to track changes in household composition, income, or energy prices, which might influence energy consumption and control for time-invariant characteristics of households and dwellings.

[5] Although approximations of energy demand via energy spending and energy consumption are common in the relevant literature, the use of a dependent variable that focuses directly on energy efficiency, such as energy performance certificates or energy efficiency labels of the building, would enhance the precision of the model.

In order to account for time trends such as evolving construction technology, material choices, and regulatory changes, two trend variables have been included: $constructionperiod_i$ and $constructionyear_i$. Accordingly, $constructionperiod_i$ is a vector of dummy variables indicating the construction period of the household's dwelling and is categorized as follows: "1900-1945", "1946-1960", "1961-1970", "1971-1980", "1981-1990", "1991-2000", "2001-2005" and "2006 and onwards". On the other hand, $constructionyear_i$ is a continuous variable representing the exact year of construction the dwelling is constructed.

In this context, our analysis is subject to a trade-off: $constructionperiod_i$ is a more comprehensive but less precise control and is available for the entire sample. $constructionyear_i$, on the other hand, is arguably a more rigorous control for our setting. However, it is not available after 2011, beyond which this information is provided as construction periods instead of a continuous measure. Therefore, we observe a decline in the number of observations for the survey years beyond 2011, when $constructionyear_i$ is introduced as a covariate. Thus, we include both controls in our model and conduct separate regressions to validate the robustness of our findings. Additionally, we include the quadratic term of $constructionyear_i$ to investigate the possibility of a non-linear impact of building age on energy demand.

Our analysis is in line with previous research encompassing a wide array of socio-economic and building characteristics that shape households' energy demand for space heating and hot water supply. Thus, in order to identify the effect of home-ownership, we control the systematic differences in observable characteristics of a dwelling apart from its construction period and year since these characteristics could also affect household energy demand. The detailed housing characteristics include house size (m^2), house type, heating method, number of rooms, main energy source, natural gas availability, presence of central heating, hot water, kitchen, toilet, and bathroom. We also control for the presence of various electrical amenities such as refrigerators, freezers, dishwashers, microwaves, washing machines, computers, and air conditioners. This set of controls is denoted as $housing_i$.

Differences in house size directly influence energy consumption, as larger houses typically require more energy for heating, cooling, and lighting. Without controlling for house size, the observed differences in energy usage between homeowners and tenants may reflect variations in dwelling size rather than tenure status. Housing type (e.g., detached house or apartment) affects energy efficiency due to differences in insulation, building materials, and shared walls. Failing to account for house type could bias results, as homeowners and tenants may occupy different types of housing that inherently vary in energy consumption patterns.

We also control for household characteristics to filter out their effects on energy spending and consumption. These controls, denoted as HH_i, include household size, number of children under 15 and 20, number of elderly members over 65, number of female members, length of stay in the current house, education level of the household head, employment status, number of working household members, average weekly working hours, total annual household income, and monthly non-energy-related expenditures. Household size is a critical factor, as larger households typically exhibit higher energy consumption due to increased use of heating, cooling, and appliances. The presence of children under the age of 15 and 20 further escalates energy consumption, reflecting the increased demand for household services. Elderly members often spend more time at home and may require higher indoor temperatures, thereby increasing energy consumption. The educational attainment of the household head can influence energy consumption patterns through greater awareness and knowledge of energy-efficient technologies.

Employment status and the number of working household members have a direct impact on household income and time spent at home, with longer working hours generally reducing residential energy consumption due to less time spent at home. Total annual household income is another pivotal control, as higher-income households tend to consume more energy, attributed to greater ownership and usage of energy-intensive appliances. Monthly non-energy-related expenditures serve as an indicator of the household's overall economic status, which correlates with energy consumption patterns. A longer tenure may result in enhanced energy efficiency due to the cumulative impact of energy investments or improved adherence to energy conservation practices.

To account for temporal variations in climate conditions, energy prices, and macroeconomic conditions, we include a vector of dummy variables, denoted as $time_i$, indicating the year of each survey. Due to Türkiye's unique geography, with coastlines on three sides and significant variations in topography, long-term mean temperatures vary dramatically across regions, creating a rich mosaic of weather patterns. Hence, we also control for regional factors that may affect energy consumption by including region-fixed effects, denoted as $region_i$. These fixed effects take a unique value for each month and region, reflecting regional differences in climate, energy policies, and building codes that may affect household energy use. The term ϵ_i represents the idiosyncratic error, capturing unobserved determinants of household energy consumption and spending.

5. RESULTS

5.1 Main Results

This section presents the results of our Ordinary Least Squares (OLS) estimations.[6] Table 5.1 presents the estimated effects of ownership status on monthly energy expenditure, controlling for the construction period and a range of characteristics. The negative coefficients in the initial models (1-3) suggest that tenants generally spend less on energy, which is in line with what is observed in descriptive statistics. However, the introduction of housing and household characteristics, as well as region-fixed effects in models (4-5), alters this relationship, indicating that the lower expenditure by tenants may also be influenced by differences in housing and household characteristics, as well as regional variations. The results in column (5) reveal a statistically significant difference in energy expenditures, with tenants spending approximately 2.5% more per month compared to homeowners. This analysis includes the building's construction period as a control and is based on 71,316 observations.

We separately examine monthly energy expenditure and non-electricity expenditure to isolate the impact of electricity on overall energy spending, thereby focusing on heating costs. This distinction helps to uncover specific patterns and inefficiencies associated with non-electricity energy sources, which may be critical for understanding split incentives in rental properties. Column (6) reports the estimation results for monthly non-electricity energy expenditures. A non-significant coefficient of 0.024 implies no notable difference between tenants and homeowners regarding non-electricity energy spending.

[6] The detailed coefficients of the covariates can be found in Appendix Table A.2.

Table 5.1 Estimation results for monthly energy expenditure

	(1)	(2)	(3)	(4)	(5)	(6)
Ownership = Tenants	-0.053***	-0.053***	-0.032***	0.027***	0.025***	0.024
	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.028)
Construction period		0.023***	-0.014***	-0.007***	-0.005***	0.011
		(0.002)	(0.002)	(0.002)	(0.002)	(0.009)
Housing characteristics	No	No	Yes	Yes	Yes	Yes
Household characteristics	No	No	No	Yes	Yes	Yes
Region FE	No	No	No	No	Yes	Yes
Observations	71320	71320	71320	71316	71316	60882
Adjusted R-squared	0.281	0.283	0.351	0.369	0.428	0.102

Notes: The table presents the OLS estimation results for the construction period sample. The dependent variable is the logarithm of monthly total energy expenditure for columns (1) through (5) and monthly total non-electricity energy expenditure for column (6). Housing characteristics include house type, house size (m^2), number of rooms, space heating type, main energy source, presence of natural gas, central heating, hot water, kitchen, toilet, and bathroom, and ownership of different appliances. Household characteristics include household income, non-energy expenditure, household size, education level, whether the household head is working or not, number of working household members, household average working hours, length of stay in the house, number of children below age 15 and 20, number of elderlies above age 65, number of females. The survey year is included as a control variable to capture the over-time variation in energy prices, climate, and macroeconomic conditions. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < 0.01$.

We extend this analysis by adding the building's exact construction year as a control. In addition to managing temporal patterns, such as advancements in construction methods, shifts in material compositions, and regulatory reforms, including the exact construction year as a control enables a precise measure of a dwelling's age. This enhances the granularity of the data, thereby facilitating more accurate control over variations linked to different time periods.

Table 5.2 presents the estimation results for monthly energy expenditure, accounting for the construction year and its square, alongside additional controls and fixed effects. The findings indicate that tenants spend approximately 1.7% more per month on energy compared to homeowners. The magnitude and significance of the tenant coefficient are slightly reduced compared to Table 5.1. This suggests, overall, a modest impact of tenure status on a household's monthly energy spending. Additionally, the inclusion of the quadratic term does not significantly alter the results, suggesting that there is no non-linear relationship between the year of construction and monthly energy expenditures. Although this analysis arguably increases the precision of the results, it also reduces the number of observations to 30,240 and narrows the time horizon to the years 2002-2011.[7]

[7] To further exploit the sample, we pooled the observations beyond the year 2011 into one category where the construction year values are missing to investigate the validity of the main results. The results are presented in Table A.2 of the Appendix section.

Table 5.2 Estimation results for monthly energy expenditure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ownership = Tenants	-0.053***	-0.059***	-0.043***	0.017*	0.018*	0.017*	0.071
	(0.005)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.060)
Construction year		0.004***	-0.001***	-0.000	-0.000	0.049	-0.071
		(0.000)	(0.000)	(0.000)	(0.000)	(0.040)	(0.245)
Construction year^2						-0.000	0.000
						(0.000)	(0.000)
Housing characteristics	No	No	Yes	Yes	Yes	Yes	Yes
Household characteristics	No	No	No	Yes	Yes	Yes	Yes
Region FE	No	No	No	No	Yes	Yes	Yes
Observations	71320	30243	30243	30240	30240	30240	25263
Adjusted R-squared	0.281	0.146	0.241	0.265	0.325	0.325	0.057

Notes: The table presents the OLS estimation results for the construction year sample. The dependent variable is the logarithm of monthly total energy expenditure for columns (1) through (5) and monthly total non-electricity energy expenditure for column (6). Housing characteristics include house type, house size (m^2), number of rooms, space heating type, main energy source, presence of natural gas, central heating, hot water, kitchen, toilet, and bathroom, and ownership of different appliances. Household characteristics include household income, non-energy expenditure, household size, education level, whether the household head is working or not, number of working household members, household average working hours, length of stay in the house, number of children below age 15 and 20, number of elderlies above age 65, number of females. The survey year is included as a control variable to capture the over-time variation in energy prices, climate, and macroeconomic conditions. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < 0.01$.

Table 5.3 presents the estimation results for monthly energy consumption (kWh) levels, controlling for the construction date details, various characteristics, and fixed effects. The results in column (1) indicate that tenants consume approximately 2.9% more energy than property owners, with these differences being significant at the 1% level. Column (2) notes that renters consume 2.3% more energy than homeowners when electricity consumption is filtered out. When we shift to the construction year sample, we do not reach conclusive results regarding the relationship between the monthly energy consumption and the tenure status.

In summary, the main results presented in this section are as follows. The findings indicate that being a renter is associated with a 2.5% increase in monthly energy spending, all other factors being equal. Under the construction year sample, the identified impact of 2.5% is reduced to 1.7% while being significant at 10%. No significant tenure-based impact was observed for monthly non-electricity expenditures. As for the monthly energy consumption levels, we observe that being a tenant is associated with 2.9% more monthly energy consumption for the construction period sample. However, this gap was not reflected in the construction year sample, as we identified no statistically notable difference between tenants and homeowners.

Table 5.3 Estimation results for monthly energy consumption (kWh)

	(1)	(2)	(3)	(4)
Ownership = Tenants	0.029***	0.023**	0.018	-0.001
	(0.009)	(0.011)	(0.016)	(0.021)
Construction period	Yes	Yes	No	No
Construction year	No	No	Yes	Yes
Housing characteristics	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	61003	51208	22190	17770
Adjusted R-squared	0.241	0.247	0.252	0.269

Notes: The table presents the OLS estimation results for the construction period sample. The dependent variable is the logarithm of energy consumption (kWh) for columns (1) and (3) and the logarithm of non-electricity energy consumption (kWh) for columns (2) and (4). Housing characteristics include house type, house size (m^2), number of rooms, space heating type, main energy source, presence of natural gas, central heating, hot water, kitchen, toilet, and bathroom, and ownership of different appliances. Household characteristics include household income, non-energy expenditure, household size, education level, whether the household head is working or not, number of working household members, household average working hours, length of stay in the house, number of children below age 15 and 20, number of elderlies above age 65, number of females. The survey year is included as a control variable to capture the over-time variation in energy prices, climate, and macroeconomic conditions. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < 0.01$.

5.2 Subsample Analysis

Next, to gain deeper insights, we analyze household energy demand by disaggregating the data by house type and household size categories.

Apartments represent the most prevalent housing type, comprising 76% of the total housing stock in our sample. Furthermore, among tenants, 87% reside in apartments. Thus, this particular residential setting is worthy of closer examination. Table 5.4 presents the results of the ordinary least squares (OLS) estimation results for this particular residence type. Columns (1) and (2) show the effect of tenure status on monthly energy expenditures, accounting for the building's construction period and construction year. Similarly, columns (3) through (4) report the effect of tenure status on monthly energy consumption in kWh.

Table 5.4 Estimation results for house type == Apartment

	(1) Apartment	(2) Apartment	(3) Apartment	(4) Apartment
Ownership = Tenants	0.034***	0.024**	0.032***	0.022
	(0.006)	(0.011)	(0.010)	(0.018)
Construction period	Yes	No	Yes	No
Construction year	No	Yes	No	Yes
Housing characteristics	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	54249	23957	45571	17285
Adjusted R-squared	0.417	0.300	0.245	0.239

Notes: The table presents the OLS estimation results for the house-type sample. The dependent variable is the logarithm of monthly total energy expenditure for columns (1) and (2) and energy consumption (kWh) for columns (3) and (4). Housing characteristics include house type, house size (m^2), number of rooms, space heating type, main energy source, presence of natural gas, central heating, hot water, kitchen, toilet, and bathroom, and ownership of different appliances. Household characteristics include household income, non-energy expenditure, household size, education level, whether the household head is working or not, number of working household members, household average working hours, length of stay in the house, number of children below age 15 and 20, number of elderlies above age 65, number of females. The survey year is included as a control variable to capture the over-time variation in energy prices, climate, and macroeconomic conditions. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < 0.01$.

The findings highlight notable trends in energy expenditure among tenants. Accordingly, tenants residing in multi-family dwellings are observed to incur 3.4% higher energy costs (a result significant at the 1% level) than their property owner peers, with this effect also apparent when controlling for construction year effects (2.4%).

With regard to energy consumption levels, columns (3) and (4) indicate that tenants in apartments exhibit a statistically insignificant 3.2% increase in energy consumption when considering the construction period. However, this difference remains statistically inconclusive when accounting for the building age. The observed difference in energy expenditure and consumption among tenants may be attributed to the apartments' vulnerability to inefficiencies associated with shared walls and centralized heating systems.

Tables 5.5 and 5.6 present the findings for households of different sizes. "No children" households are defined as those without children under the age of 15 or 20 years old. "Small to medium size families" are defined as their size equal to or smaller than the mean family size (3.56 for the entire sample), while "large families" are those that exceed this threshold. Controlling for the construction period in columns (1) and (2), tenant households without children exhibit a non-significant increase in energy expenditures. Small to medium-sized tenant households show a statistically significant increase of 1.6% (significant at the 5% level), with no significant findings in the construction year sample. The divergence in energy expenditures between large tenant households and homeowners is the most pronounced, with tenant households spending 3.6% more on energy-related expenses. This finding remains consistent in the construction year sample, albeit with a slight reduction in magnitude.

Table 5.5 Estimation results for different household sizes

	(1) No children	(2) Small to medium	(3) Large	(4) No children	(5) Small to medium	(6) Large
Ownership = Tenants	0.001	0.016**	0.036***	-0.017	0.009	0.032**
	(0.010)	(0.008)	(0.008)	(0.019)	(0.015)	(0.013)
Construction period	Yes	Yes	Yes	No	No	No
Construction year	No	No	No	Yes	Yes	Yes
Housing characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28744	36854	34462	11043	14365	15875
Adjusted R-squared	0.402	0.406	0.459	0.306	0.306	0.348

Notes: The table presents the OLS estimation results for the family size subsamples. Categorization is made with respect to mean family size. The dependent variable is the logarithm of monthly total energy expenditure. Housing characteristics include house type, house size (m^2), number of rooms, space heating type, main energy source, presence of natural gas, central heating, hot water, kitchen, toilet, and bathroom, and ownership of different appliances. Household characteristics include household income, non-energy expenditure, household size, education level, whether the household head is working or not, number of working household members, household average working hours, length of stay in the house, number of children below age 15 and 20, number of elderlies above age 65, number of females. The survey year is included as a control variable to capture the over-time variation in energy prices, climate, and macroeconomic conditions. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < 0.01$.

Table 5.6 presents the results of further analysis examining the relationship between energy consumption (measured in kWh) and household size. The findings indicate that tenants from large families consume, on average, 3.9% more energy than homeowners. This effect remains consistent in the construction year sample, where the magnitude is slightly reduced to 3.8%.

Table 5.6 Estimation results for different household sizes

	(1) No children	(2) Small to medium	(3) Large	(4) No children	(5) Small to medium	(6) Large
Ownership = Tenants	0.015	0.022*	0.039***	-0.028	0.005	0.038*
	(0.016)	(0.013)	(0.013)	(0.031)	(0.025)	(0.022)
Construction period	Yes	Yes	Yes	No	No	No
Construction year	No	No	No	Yes	Yes	Yes
Housing characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	25111	32123	28880	8183	10627	11563
Adjusted R-squared	0.243	0.240	0.250	0.251	0.242	0.268

Notes: The table presents the OLS estimation results for the family size subsamples. Categorization is made with respect to mean family size. The dependent variable is the logarithm of energy consumption (kWh). Housing characteristics include house type, house size (m^2), number of rooms, space heating type, main energy source, presence of natural gas, central heating, hot water, kitchen, toilet, and bathroom, and ownership of different appliances. Household characteristics include household income, non-energy expenditure, household size, education level, whether the household head is working or not, number of working household members, household average working hours, length of stay in the house, number of children below age 15 and 20, number of elderlies above age 65, number of females. The survey year is included as a control variable to capture the over-time variation in energy prices, climate, and macroeconomic conditions. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < 0.01$.

In Table 5.7, we delve more deeply into the intersection between housing type and family size by examining the differences between tenants with large household sizes residing in apartments compared to homeowner counterparts. The results indicate a significant impact, with tenants experiencing a 4.8% increase in energy-related expenses under the construction period sample and a 4.4% increase under the construction year sample. This trend is similarly reflected in columns (3) and (4), which highlight corresponding patterns in energy consumption.

These findings concerning dwellings occupied by large families may introduce novel dimensions to policy discussions. Given their higher propensity for energy consumption, these residences could benefit from targeted rental regulations. Implementing policies tailored to this specific rental setting could effectively distribute the burden of energy inefficiency more equitably between tenants and property owners.

Table 5.7 Estimation results for household size and house type subsample

	(1)	(2)	(3)	(4)
Ownership = Tenants	0.048***	0.044***	0.046***	0.052**
	(0.009)	(0.014)	(0.014)	(0.024)
Construction period	Yes	No	Yes	No
Construction year	No	Yes	No	Yes
Housing characteristics	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	25239	11931	20778	8563
Adjusted R-squared	0.435	0.309	0.232	0.244

Notes: The table presents the OLS estimation results for household size and house type subsample. The household size category is "large", and the house type category is "apartment". The dependent variable is the logarithm of energy expenditure for columns (1) and (2) and energy consumption (kWh) for columns (3) and (4). Housing characteristics include house size (m^2), number of rooms, space heating type, main energy source, presence of natural gas, central heating, hot water, kitchen, toilet, and bathroom, and ownership of different appliances. Household characteristics include household income, non-energy expenditure, education level, whether the household head is working or not, number of working household members, household average working hours, length of stay in the house, number of children below age 15 and 20, number of elderlies above age 65, number of females. The survey year is included as a control variable to capture the over-time variation in energy prices, climate, and macroeconomic conditions. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < 0.01$.

5.3 Heterogeneous Effects

This section presents a detailed examination of households utilizing distinct heating methods, with the aim of enhancing the interpretability of our estimated coefficients by disaggregating total energy expenditures. Households utilizing electrical equipment for heating are reintegrated into the analysis. Table 5.8 presents the regression results corresponding to different heating modalities. Each model's dependent variable represents the logarithm of expenditures on the respective energy source, namely, wood and coal expenditures for stove heating, non-electricity energy spending for central heating, natural gas costs for individual boiler heating, and electricity expenditures for air conditioner heating.

Table 5.8 presents the Ordinary Least Squares (OLS) estimates of energy expenditures across diverse heating systems, revealing notable distinctions between tenant-occupied and homeowner-occupied residences. Controlling for the construction period of dwellings, our findings indicate that tenants spend 7% more on gas when gas-powered appliances are employed for heating compared to homeowners. This disparity persists in the construction year sample, albeit with increased statistical significance. Similarly, for dwellings where electricity serves as the principal energy source, encompassing both heating and cooling functions, tenants exhibit a 10.4% higher expenditure on electricity relative to homeowners. This effect is further evidenced in the construction year sample, with a notable magnitude of 12.9%.

Table 5.8 Estimation results for different heating methods

	(1) Stove	(2) Central heating	(3) Individual boiler	(4) Air conditioner	(5) Stove	(6) Central heating	(7) Individual boiler	(8) Air conditioner
Ownership = Tenants	-0.022	-0.067	0.070***	0.104***	0.027	-0.056	0.063**	0.129***
	(0.028)	(0.056)	(0.013)	(0.019)	(0.055)	(0.097)	(0.026)	(0.035)
Construction period	Yes	Yes	Yes	Yes	No	No	No	No
Construction year	No	No	No	No	Yes	Yes	Yes	Yes
Housing characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9968	13955	25328	4088	3258	7507	6996	1459
Adjusted R-squared	0.290	0.064	0.432	0.426	0.248	0.049	0.462	0.412

Notes: The table presents the OLS estimation results for the heating method subsamples. The dependent variables measure the logarithm amount of non-electricity spending on the corresponding heating method (wood/coal spending when the stove is the heating method, non-electricity energy spending for central heating, gas spending for individual boiler, and electricity spending when electricity-heating is used). Households using wood as the main energy source are excluded from the sample. Housing characteristics include house type, house size (m^2), number of rooms, space heating type, main energy source, presence of natural gas, central heating, hot water, kitchen, toilet, and bathroom, and ownership of different appliances. Household characteristics include household income, non-energy expenditure, household size, education level, whether the household head is working or not, number of working household members, household average working hours, length of stay in the house, number of children below age 15 and 20, number of elderlies above age 65, number of females. The survey year is included as a control variable to capture the over-time variation in energy prices, climate, and macroeconomic conditions. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < 0.01$.

Furthermore, an analysis of energy source heterogeneity reveals that tenants using stoves and central heating do not differ significantly in terms of energy spending from their homeowner peers. The underlying reason for the unobserved difference between tenants and homeowners when the heating methods are stoves and central heating may be that these systems are inherently prone to energy inefficiency, regardless of the tenure status. The energy expenditures in the central heating setting are typically shared among the households, and thus, no party has sufficient incentive to economize their consumption. On the other hand, stoves are obsolete devices well-known for their poor fuel efficiency.

6. ROBUSTNESS CHECKS

Two additional tests were executed to further validate these findings. First, we run the same analysis on the entire sample without excluding the wood from the energy source alternatives. This maneuver doubles the number of observations from 71,320 to 142,389 and enables us to check whether we can detect any divergent patterns on a broader set of observations compared to the previously identified results. In Table 6.1, we present the impact of tenure status on total monthly energy consumption (kWh), focusing on different energy source categories. The construction period sample reveals disparities between tenants and homeowners in terms of energy consumption patterns. Specifically, in dwellings where wood is the primary energy source, tenants exhibit a 4.4% higher energy consumption. Similarly, for homes that rely on natural gas for heating and cooling, tenant-occupied properties consume 5.1% more energy on a monthly basis compared to owner-occupied ones. Furthermore, tenant-occupied residences that utilize electricity for heating purposes exhibit a 5.2% higher consumption than owner-occupied counterparts.

Table 6.1 Estimation results for different primary energy sources

	(1) Wood	(2) Coal	(3) N. Gas	(4) Elect.	(5) Other	(6) Wood	(7) Coal	(8) N. Gas	(9) Elect.	(10) Other
Ownership = Tenants	0.044***	0.012	0.051***	0.052***	-0.045	0.023	0.034	0.052**	0.069**	-0.046
	(0.012)	(0.016)	(0.011)	(0.017)	(0.046)	(0.016)	(0.024)	(0.024)	(0.028)	(0.058)
Construction period	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Construction year	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Housing characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	42768	21042	34479	6497	3048	23245	9174	9911	2761	1772
Adjusted R-squared	0.204	0.278	0.293	0.183	0.126	0.233	0.300	0.299	0.203	0.144

Notes: The table presents the OLS estimation results for the energy source subsamples. The dependent variables measure the logarithm amount of monthly energy consumption (kWh). Households using wood as the main energy source are included in the sample. Housing characteristics include house type, size, number of rooms, space heating type, presence of natural gas, central heating, hot water, kitchen, toilet, and bathroom, and ownership of different appliances. Housing characteristics include house type, house size (m^2), number of rooms, space heating type, main energy source, presence of natural gas, central heating, hot water, kitchen, toilet, and bathroom, and ownership of different appliances. Household characteristics include household income, non-energy expenditure, household size, education level, whether the household head is working or not, number of working household members, household average working hours, length of stay in the house, number of children below age 15 and 20, number of elderlies above age 65, number of females. The survey year is included as a control variable to capture the over-time variation in energy prices, climate, and macroeconomic conditions. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < 0.01$.

Shifting to the construction year sample, we observe a similar trend in the impact on natural gas-powered dwellings, standing at 5.2%, with a slight loss in its significance level. Further, the impact of electricity as the primary energy source remains significant at 6.9% in column (9). No noticeable impact is found for the wood category in the construction year sample. Thus, systematic disparities in energy consumption between tenants and homeowners observed across energy source categories do not diverge from the results we identified in our analysis. It can be concluded that notable differences exist in energy consumption among dwellings heated by central heating systems and air conditioners.

The second test involves an application of propensity score matching. In our analysis throughout the study, we imposed housing, household, and regional controls to mitigate potential confounding effects on our results. However, this threat has not been fully eliminated. To address this, we conducted a propensity score matching and utilized different matching parameters to compare the robustness and sensitivity of the results. First, we estimate propensity scores to balance covariates between the treated (owned houses) and control (rented houses) groups. The logistic regression setting models the likelihood of receiving treatment (ownership status) given the covariates (housing, household, and regional controls in this case) and guides us in establishing comparable groups.

Under the less restrictive setting (1), we employ a larger caliper width and a greater number of neighbors, leading to a greater number of matches. The regression models on matched samples estimate the treatment effect of ownership status on energy demand outcomes while controlling for covariates. In contrast, in setting (2), the matching criteria are highly restrictive, with a narrow caliper ensuring that only closely comparable units are considered. We match each treated unit (owned houses) to the nearest control unit (rented houses) within a caliper of 0.01 using the previously estimated propensity scores. This reduces bias but may result in the discarding of many treated units without suitable matches.

Table 6.2 PSM estimation results for energy demand variables

	(1) Nearest Neighbor (N=5) Radius (0.1)	(2) Nearest Neighbor (N=1) Radius (0.01)	(3) Nearest Neighbor (N=5) Radius (0.1)	(4) Nearest Neighbor (N=1) Radius (0.01)
Ownership = Tenants	-0.043	0.029*	-0.058	-0.013
	(0.032)	(0.016)	(0.057)	(0.028)
Housing characteristics	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	8392	10240	6315	7649
Adjusted R-squared	0.279	0.281	0.189	0.191

Notes: The table presents the PSM estimation results for the construction year sample. The dependent variable is the logarithm of monthly energy expenditures for columns (1) and (2) and the logarithm of energy consumption (kWh) for columns (3) and (4). Housing characteristics include house type, size, number of rooms, space heating type, main energy source, presence of natural gas, central heating, hot water, kitchen, toilet, and bathroom, and ownership of different appliances. Household characteristics include household income, non-energy expenditure, household size, education level, whether the household head is working or not, number of working household members, household average working hours, length of stay in the house, number of children below age 15 and 20, number of elderlies above age 65, number of females. The survey year is included as a control variable to capture the over-time variation in energy prices, climate, and macroeconomic conditions. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < 0.01$.

Table 6.2 presents the PSM results under the construction year sample, which largely support our earlier findings. When a less stringent matching criterion is employed in column (1), the effect is found to be statistically insignificant. However, in column (2), we observe that being a tenant is associated with a 2.9% increase in energy expenditure. This finding is in alignment with the results of our primary analysis, in which we estimated the effect to be 1.7% (significant at the 10% level). With regard to energy consumption outcomes, columns (3) and (4) demonstrate no statistically significant differences between tenants and homeowners in terms of monthly energy consumption levels. These results are consistent with those of our main estimation analysis. Nevertheless, it is essential to note that the PSM approach cannot entirely eliminate the risk of bias stemming from unobservable individual characteristics. Factors influencing tenure choice (e.g., income, household size) could still simultaneously affect energy expenditures, potentially introducing bias into the results if not adequately controlled for.

7. CONCLUSION

In this study, we focused on the split incentive problem within the Turkish residential sector. To that end, we examined the relationship between tenure status and energy efficiency using household-level data. The analytical framework included key variables such as construction period and year, house size, house type, heating method, and detailed household attributes, including household size, number of children and elderly members, income, and educational attainment. Overall, we find preliminary evidence regarding the presence of split incentives in the residential domain.

The study's key findings indicate that being a tenant is associated with a 2.5% increase in monthly energy expenditures, controlling for housing, household, and regional factors. This gap is also observed when accounting for the exact building construction year. As for the monthly energy consumption levels, tenants show a 2.9% higher monthly consumption in the initial analysis. However, this identification is not further supported when the construction year is introduced into the setting.

A closer inspection of these general patterns via subsample analysis shows that tenants in apartments exhibit a higher energy expenditure than homeowners. Furthermore, large households who are in tenant status also exhibit a pronounced disparity, spending more on energy and consuming more. For large tenant families living in apartments, we observe a 4.8% increase in energy expenditures, a difference that is also reflected in their energy consumption figures. Heterogeneity analysis further reveals varying patterns in energy expenditure between tenants and homeowners, particularly concerning natural gas and electricity usage. However, tenants using stoves and central heating do not display any statistically notable disparity.

Two tests were conducted to stress the robustness of the findings. Broader set of observations was analyzed from the standpoint of total monthly energy consumption without any exclusions. The results were in line with the findings from heterogeneity analysis. Propensity score matching (PSM) results were largely consistent with the main results, where the tenants exhibited higher monthly energy spending.

The ultimate result is higher energy spending for tenant-occupied buildings. These findings align with our expectations and indicate a potential presence of the efficiency problem we elaborated on in Case 2. This is likely because "bills included" rental contracts are far from being the norm in Türkiye. Thus, the observed energy gap within the rental units indicates a potential split incentive problem. The results found throughout the study reveal promising policy insights and underline the need to tackle the problem by considering the intricate characteristics of dwellings and households. Targeted policies, such as calibrating the rental contracts to align the interests of two parties for certain scenarios, may mitigate the observed efficiency disparities. For instance, legislative measures could mandate landlords to proactively install necessary thermal efficiency upgrades in multi-family apartments occupied by large households that typically have higher energy demands. Similarly, in residences where individual boilers are used for heating, regulations may require tenants and landlords to maintain these appliances within reasonable energy efficiency standards, as indicated by the energy efficiency labels.

Future studies investigating the split incentive framework in the context of the Turkish residential market could address several key limitations. Firstly, transitioning from cross-sectional to longitudinal data would facilitate a more nuanced understanding of how household energy consumption patterns evolve over time. Secondly, obtaining detailed information on rental contract types and dwelling efficiency characteristics would enable more precise comparisons between tenants and homeowners. Lastly, employing standardized energy efficiency measures, such as energy performance certificates, would refine the assessment of differential energy consumption patterns across tenure groups.

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APPENDIX A

Table A.1 Descriptive statistics by ownership status

	Survey year: 2019			Entire sample		
	(Owners)	(Tenants)	(t-test)	(Owners)	(Tenants)	(t-test)
Total monthly household energy expenditure (TL)	198.316	191.363	**	138.086	136.542	*
	(92.31)	(94.26)		(91.44)	(90.46)	
Annual household net income (TL)	6.6e+04	5.8e+04	***	3.9e+04	3.4e+04	***
	(43608.8)	(43252.6)		(37238.2)	(31766.1)	
Monthly household expenditure (TL)	4606.982	4460.472		2786.418	2670.966	***
	(3015.3)	(2886.7)		(2372.4)	(2234.8)	
Monthly other expenditures (TL)	4408.666	4269.109		2648.333	2534.424	***
	(3006.1)	(2878.4)		(2341.6)	(2205.2)	
Monthly electricity expenditure (TL)	100.955	98.019	*	61.412	61.677	
	(45.50)	(46.83)		(43.19)	(41.53)	
Monthly non-electricity expenditure (TL)	97.361	93.344		76.673	74.866	**
	(86.14)	(85.04)		(75.62)	(75.41)	
Monthly gas expenditure (TL)	55.593	68.017	***	40.970	44.712	***
	(81.64)	(85.65)		(69.86)	(72.98)	
Monthly house maintenance expenditure (TL)	32.515	4.622	***	30.505	6.087	***
	(191.7)	(19.16)		(144.8)	(46.74)	
Monthly coal/wood expenditure (TL)	23.735	13.834	***	17.857	15.179	***
	(49.67)	(38.45)		(42.35)	(38.35)	
Monthly LPG expenditure (TL)	17.762	11.313	***	14.062	11.953	***
	(38.61)	(31.97)		(27.29)	(25.06)	
Monthly heating oil expenditure (TL)	0.270	0.180		3.784	3.022	***
	(5.917)	(4.030)		(21.74)	(18.63)	
Monthly energy consumption (kWh)	754.238	749.218		1016.057	969.342	***
	(559.7)	(571.0)		(923.5)	(871.5)	
Monthly electricity consumption (kWh)	168.028	163.141	*	193.145	186.790	***
	(75.73)	(77.95)		(119.1)	(111.9)	
Monthly gas consumption (kWh)	379.069	463.779	***	485.983	499.385	
	(556.7)	(584.0)		(800.9)	(783.8)	
Monthly non-electricity consumption (kWh)	586.210	586.076		822.912	782.552	***
	(562.5)	(572.6)		(914.3)	(863.5)	
House type==detached	0.428	0.192	***	0.282	0.132	***
	(0.495)	(0.394)		(0.450)	(0.339)	
House type==apartment	0.572	0.808	***	0.718	0.868	***
	(0.495)	(0.394)		(0.450)	(0.339)	
Heating type==stove	0.400	0.295	***	0.335	0.337	
	(0.490)	(0.456)		(0.472)	(0.473)	
Heating type==central heating	0.104	0.123	*	0.219	0.227	*
	(0.305)	(0.328)		(0.414)	(0.419)	
Heating type==individual boiler	0.497	0.582	***	0.446	0.436	*
	(0.500)	(0.493)		(0.497)	(0.496)	
Main energy source==coal	0.351	0.222	***	0.353	0.338	***
	(0.477)	(0.416)		(0.478)	(0.473)	
Main energy source==natural gas	0.587	0.700	***	0.524	0.548	***
	(0.492)	(0.458)		(0.499)	(0.498)	
Main energy source==electricity	0.026	0.065	***	0.038	0.070	***
	(0.158)	(0.246)		(0.192)	(0.255)	
Main energy source==other	0.036	0.013	***	0.085	0.044	***
	(0.187)	(0.112)		(0.279)	(0.204)	
Secondary energy source==wood	0.278	0.163	***	0.112	0.095	***
	(0.448)	(0.369)		(0.315)	(0.293)	
Secondary energy source==coal	0.058	0.056		0.224	0.234	**
	(0.234)	(0.230)		(0.417)	(0.423)	
Secondary energy source==natural gas	0.582	0.694	***	0.521	0.544	***
	(0.493)	(0.461)		(0.500)	(0.498)	
Secondary energy source==electricity	0.028	0.072	***	0.045	0.077	***
	(0.166)	(0.259)		(0.208)	(0.267)	
Secondary energy source==other	0.053	0.016	***	0.098	0.051	***
	(0.225)	(0.124)		(0.297)	(0.219)	
Natural gas==0	0.407	0.285	***	0.459	0.433	***
	(0.491)	(0.452)		(0.498)	(0.495)	
Natural gas==1	0.593	0.715	***	0.541	0.567	***
	(0.491)	(0.452)		(0.498)	(0.495)	
Central heating==0	0.000	0.000		0.211	0.235	***

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Table A.1 (continued)

	Survey year: 2019			Entire sample		
	(Owners)	(Tenants)	(t-test)	(Owners)	(Tenants)	(t-test)
	(0)	(0)		(0.408)	(0.424)	
Central heating==1	0.605	0.711	***	0.670	0.663	
	(0.489)	(0.454)		(0.470)	(0.473)	
Central heating==2	0.395	0.289	***	0.120	0.102	***
	(0.489)	(0.454)		(0.325)	(0.303)	
Hot water method==natural gas	0.564	0.669	***	0.578	0.602	***
	(0.496)	(0.471)		(0.494)	(0.490)	
Hot water method==LPG	0.013	0.011		0.040	0.044	*
	(0.114)	(0.104)		(0.196)	(0.205)	
Hot water method==electricity	0.132	0.213	***	0.156	0.257	***
	(0.339)	(0.409)		(0.362)	(0.437)	
Hot water method==solar	0.253	0.088	***	0.177	0.074	***
	(0.435)	(0.284)		(0.381)	(0.261)	
Hot water method==other	0.037	0.019	***	0.050	0.024	***
	(0.189)	(0.137)		(0.218)	(0.152)	
Energy used in kitchen==natural gas	0.578	0.690	***	0.594	0.627	***
	(0.494)	(0.463)		(0.491)	(0.484)	
Energy used in kitchen==LPG	0.369	0.294	***	0.367	0.360	
	(0.483)	(0.456)		(0.482)	(0.480)	
Energy used in kitchen==electricity	0.009	0.008		0.009	0.007	
	(0.0940)	(0.0895)		(0.0932)	(0.0848)	
Energy used in kitchen==other	0.044	0.007	***	0.030	0.005	***
	(0.205)	(0.0862)		(0.171)	(0.0732)	
Floor type==parquet	0.669	0.727	***	0.634	0.608	***
	(0.471)	(0.446)		(0.482)	(0.488)	
Floor type==ceramic tile	0.073	0.101	***	0.073	0.093	***
	(0.260)	(0.302)		(0.261)	(0.290)	
Floor type==PVC	0.020	0.043	***	0.057	0.107	***
	(0.141)	(0.204)		(0.233)	(0.309)	
Floor type==carpet	0.003	0.002		0.013	0.016	*
	(0.0590)	(0.0416)		(0.114)	(0.125)	
Floor type==concrete	0.148	0.048	***	0.099	0.050	***
	(0.355)	(0.214)		(0.299)	(0.219)	
Floor type==tessellation	0.003	0.008	*	0.009	0.021	***
	(0.0590)	(0.0896)		(0.0947)	(0.142)	
Floor type==other	0.005	0.000	**	0.015	0.003	***
	(0.0739)	(0)		(0.120)	(0.0574)	
Employment status==0	0.461	0.302	***	0.393	0.212	***
	(0.499)	(0.459)		(0.488)	(0.409)	
Employment status==1	0.539	0.698	***	0.607	0.788	***
	(0.499)	(0.459)		(0.488)	(0.409)	
Education==no education	0.146	0.074	***	0.097	0.048	***
	(0.354)	(0.261)		(0.296)	(0.213)	
Education==primary school	0.425	0.259	***	0.410	0.296	***
	(0.494)	(0.438)		(0.492)	(0.456)	
Education==secondary school	0.121	0.165	***	0.115	0.135	***
	(0.326)	(0.371)		(0.319)	(0.341)	
Education==high school	0.086	0.139	***	0.110	0.161	***
	(0.281)	(0.346)		(0.313)	(0.367)	
Education==vocational high school	0.068	0.093	***	0.086	0.096	***
	(0.251)	(0.290)		(0.280)	(0.295)	
Education==2-year university	0.045	0.063	**	0.049	0.063	***
	(0.207)	(0.244)		(0.217)	(0.244)	
Education==university	0.096	0.183	***	0.117	0.179	***
	(0.295)	(0.386)		(0.321)	(0.383)	
Education==master-PhD	0.013	0.025	***	0.016	0.023	***
	(0.114)	(0.157)		(0.124)	(0.149)	
Length of stay in the current house	17.267	4.446	***	13.928	4.048	***
	(14.43)	(5.141)		(12.18)	(4.568)	
House size (m^2)	112.502	102.758	***	111.197	105.034	***
	(34.39)	(30.57)		(33.12)	(28.21)	
Number of rooms	3.618	3.425	***	3.663	3.516	***
	(0.778)	(0.711)		(0.762)	(0.680)	
Number of household members	3.430	3.170	***	3.661	3.442	***
	(1.821)	(1.431)		(1.809)	(1.453)	
Number of working members	1.088	1.165	**	1.156	1.265	***
	(0.955)	(0.740)		(0.974)	(0.768)	
Average weekly working hours of members	14.612	20.172	***	15.049	20.394	***
	(13.60)	(15.65)		(13.13)	(14.60)	
Number of children (age<15)	0.736	0.891	***	0.837	0.986	***
	(1.137)	(1.068)		(1.182)	(1.056)	
Number of children (age<20)	1.033	1.073		1.176	1.247	***
	(1.371)	(1.149)		(1.412)	(1.180)	
Number of elderly (age>64)	0.489	0.164	***	0.376	0.141	***
	(0.714)	(0.431)		(0.645)	(0.399)	

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Table A.1 (continued)

	Survey year: 2019			Entire sample		
	(Owners)	(Tenants)	(t-test)	(Owners)	(Tenants)	(t-test)
Number of female members	1.734	1.588	***	1.883	1.739	***
	(1.065)	(0.968)		(1.137)	(1.018)	
Number of refrigerators	1.010	1.000	**	1.006	0.998	***
	(0.143)	(0.107)		(0.148)	(0.105)	
Number of freezers	0.409	0.204	***	0.214	0.109	***
	(0.499)	(0.406)		(0.415)	(0.315)	
Number of dishwashers	0.733	0.729		0.654	0.619	***
	(0.445)	(0.447)		(0.480)	(0.487)	
Number of microwaves	0.236	0.237		0.190	0.181	**
	(0.428)	(0.429)		(0.395)	(0.388)	
Number of washing machines	0.988	0.986		0.963	0.974	***
	(0.135)	(0.117)		(0.200)	(0.162)	
Number of computers	0.445	0.616	***	0.494	0.579	***
	(0.657)	(0.749)		(0.616)	(0.649)	
Number of air conditioners	0.280	0.183	***	0.192	0.108	***
	(0.638)	(0.476)		(0.515)	(0.367)	
Toilet==1	0.926	0.983	***	0.939	0.986	***
	(0.262)	(0.130)		(0.239)	(0.119)	
Kitchen==1	0.994	0.999	**	0.988	0.998	***
	(0.0769)	(0.0240)		(0.109)	(0.0483)	
Bathroom==1	1.011	1.004	**	0.986	0.998	***
	(0.106)	(0.0634)		(0.154)	(0.0705)	
Number of observations	4037	1736		50824	20496	

Notes: The table presents the descriptive statistics of the means for the survey year 2019 and the entire sample, respectively, while differentiating between homeowners and tenants. t-test results in each column indicate the statistical significance of the mean differences between the two groups. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard deviations are given in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.2 Detailed presentation of the estimates from the main regressions

	(1) Log of monthly energy expenditure	(2) Log of monthly energy expenditure	(3) Log of monthly energy consumption	(4) Log of monthly energy consumption
Ownership = Tenants	0.025***	0.017*	0.029***	0.018
	(0.006)	(0.010)	(0.009)	(0.016)
Log of house size (m^2)	0.077***	0.083***	0.146***	0.180***
	(0.012)	(0.021)	(0.019)	(0.035)
Number of rooms	0.004	0.000	-0.011	-0.036***
	(0.004)	(0.007)	(0.007)	(0.013)
House type: Apartment	-0.022***	-0.018	-0.074***	-0.114***
	(0.007)	(0.012)	(0.011)	(0.020)
Heating type: Central heating	0.127***	0.165***	0.054	0.011
	(0.019)	(0.036)	(0.033)	(0.083)
Heating type: Individual boiler	0.021	0.019	0.002	0.041
	(0.019)	(0.036)	(0.033)	(0.083)
Main energy source: Natural gas	-0.085***	0.043	-0.448***	-0.273***
	(0.017)	(0.031)	(0.026)	(0.049)
Main energy source: Electricity	-0.199***	-0.167***	-0.778***	-0.645***
	(0.011)	(0.017)	(0.019)	(0.029)
Main energy source: Other	-0.178***	-0.105***	-0.667***	-0.495***
	(0.009)	(0.014)	(0.018)	(0.027)
Natural gas==1	-0.066***	-0.124***	0.343***	0.408***
	(0.017)	(0.031)	(0.026)	(0.048)
Central heating system==1	0.110***	0.083**	0.053	-0.019
	(0.020)	(0.036)	(0.033)	(0.082)
Hot water system==1	0.121***	0.095***	0.204***	0.181***
	(0.010)	(0.014)	(0.017)	(0.026)
Toilet==1	0.062***	0.051**	0.097***	0.090**
	(0.013)	(0.023)	(0.021)	(0.038)
Kitchen==1	0.051*	0.055	0.149***	0.165**
	(0.026)	(0.039)	(0.046)	(0.072)
Bathroom==1	-0.023	0.003	-0.016	0.062
	(0.023)	(0.031)	(0.039)	(0.052)
Number of refrigerators	0.029*	-0.018	0.041	-0.001
	(0.016)	(0.026)	(0.027)	(0.045)
Number of freezers	0.055***	0.061***	0.044***	0.074***
	(0.006)	(0.013)	(0.009)	(0.022)
Number of dishwashers	0.086***	0.069***	0.080***	0.057***
	(0.005)	(0.009)	(0.009)	(0.015)
Number of microwaves	-0.010*	-0.017	-0.021**	-0.003
	(0.006)	(0.012)	(0.009)	(0.019)
Number of washing machines	0.046***	0.047**	-0.012	-0.067*
	(0.014)	(0.020)	(0.024)	(0.036)
Number of computers	0.026***	0.045***	0.025***	0.069***
	(0.004)	(0.008)	(0.006)	(0.013)
Number of air conditioners	-0.018***	-0.023**	-0.062***	-0.048***
	(0.005)	(0.010)	(0.007)	(0.016)
Number of household members	0.035***	0.033***	0.021***	0.015*
	(0.003)	(0.005)	(0.005)	(0.009)
Working==1	0.003	-0.016	0.015	-0.002
	(0.007)	(0.011)	(0.010)	(0.018)
Number of working members	0.007	0.008	0.009	0.006
	(0.005)	(0.008)	(0.007)	(0.013)
Average weekly working hours of members	-0.002***	-0.002***	-0.002***	-0.001
	(0.000)	(0.000)	(0.000)	(0.001)
Education level: Primary school	0.041***	0.055***	0.086***	0.119***
	(0.009)	(0.015)	(0.013)	(0.025)
Education level: Secondary school	0.043***	0.066***	0.075***	0.111***
	(0.010)	(0.018)	(0.016)	(0.030)
Education level: Highschool	0.046***	0.068***	0.085***	0.128***
	(0.011)	(0.018)	(0.017)	(0.030)
Education level: Vocational high school	0.044***	0.050**	0.076***	0.071**
	(0.011)	(0.020)	(0.018)	(0.032)
Education level: 2-year University	0.042***	0.089***	0.047**	0.082**
	(0.013)	(0.023)	(0.020)	(0.037)
Education level: University	0.031***	0.066***	0.043**	0.069**
	(0.011)	(0.020)	(0.018)	(0.033)
Education level: Master-PhD	0.003	0.046	-0.007	0.003
	(0.019)	(0.035)	(0.030)	(0.059)
Log of annual household net income	0.106***	0.129***	0.109***	0.138***
	(0.005)	(0.009)	(0.009)	(0.015)
Log of other expenditures	0.086***	0.093***	0.090***	0.100***
	(0.005)	(0.009)	(0.008)	(0.016)
Number of children (age<15)	-0.010**	-0.010	0.009	0.008
	(0.004)	(0.007)	(0.007)	(0.011)
Number of children (age<20)	-0.022***	-0.020***	-0.034***	-0.026**
	(0.005)	(0.007)	(0.007)	(0.013)
Number of elderly (age>64)	0.018***	0.017**	0.032***	0.027**
	(0.004)	(0.007)	(0.006)	(0.012)
Number of female members	0.007**	0.009*	0.015***	0.027***
	(0.003)	(0.005)	(0.005)	(0.008)
The length of stay in the current house	0.002***	0.002***	0.003***	0.005***
	(0.000)	(0.001)	(0.000)	(0.001)
Constant	2.133***	-45.797	3.425***	1.536
	(0.403)	(39.281)	(0.592)	(1.334)
Construction period	Yes	No	Yes	No
Construction year	No	Yes	No	Yes
Regional FE	Yes	Yes	Yes	Yes
Observations	71316	30240	61003	22190
Adjusted R-squared	0.428	0.325	0.241	0.252

Notes: The table presents the OLS estimation results for the construction period and construction year samples. The dependent variable is the logarithm of monthly total energy expenditure for columns (1) and (2) and monthly total energy consumption in columns (3) and (4). The omitted categories are "homeowners" for ownership status, "detached" for house type, "stove" for heating type, and "no education" for education level. Survey year indicators are excluded from the output. The survey year is included as a control variable to capture the over-time variation in energy prices, climate, and macroeconomic conditions. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < 0.01$.

Table A.3 Pooled sample estimation results

	(1) Log of monthly energy expenditure	(2) Log of monthly energy expenditure	(3) Log of monthly energy consumption	(4) Log of monthly energy consumption
Ownership = Tenants	0.024***	0.027***	0.029***	0.022**
	(0.006)	(0.006)	(0.009)	(0.009)
Construction period	Yes	No	Yes	No
Construction year	No	Yes	No	Yes
Housing characteristics	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	69058	69058	61003	61003
Adjusted R-squared	0.417	0.417	0.241	0.241

Notes: The table presents the OLS estimation results for the pooled sample. Observations beyond the year 2011 are pooled into one category to exploit the entire sample while imposing construction year as a control. The dependent variable is the logarithm of monthly total energy expenditure for columns (1) and (2) and the logarithm of energy consumption (kWh) for columns (3) and (4). Housing characteristics include house type, house size (m^2), number of rooms, space heating type, main energy source, presence of natural gas, central heating, hot water, kitchen, toilet, and bathroom, and ownership of different appliances. Household characteristics include household income, non-energy expenditure, household size, education level, whether the household head is working or not, number of working household members, household average working hours, length of stay in the house, number of children below age 15 and 20, number of elderlies above age 65, number of females. The survey year is included as a control variable to capture the over-time variation in energy prices, climate, and macroeconomic conditions. The analysis relies on data from the Turkish Statistical Office Household Budget Surveys from 2002 through 2019. Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < 0.01$.