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Faculteit Bedrijfseconomische Wetenschappen

master handelsingenieur in de beleidsinformatica

Masterthesis

The Economic Effects of the Energy Crisis on Short-term Rental Industry: An Analysis of Airbnb in Madrid

Aegon Leyssens

Scriptie ingediend tot het behalen van de graad van master handelsingenieur in de beleidsinformatica

PROMOTOR :

Prof. dr. Stephan BRUNS

BEGELEIDER :

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This master's thesis marks the final step of my Business Engineering and Information Systems studies at Hasselt University. Throughout this journey, I have developed essential skills in data analysis, critical thinking, and research methodology. I would like to sincerely thank my supervisor, Prof. Dr. Stephan Bruns, and my co-supervisor, Mr. Tuan Nguyen, for their invaluable guidance and support. I am also grateful to Hasselt University for providing an inspiring academic environment. Lastly, I want to express my deepest appreciation to my friends and family for their constant encouragement and support throughout this journey.

Summary

Objective and Methodology

This master's thesis investigates the impact of the European energy crisis, which peaked in 2022, on rental prices, market demand, and revenues from Airbnb listings in Madrid. External shocks, including the COVID-19 pandemic and the Russian invasion of Ukraine, primarily triggered this energy crisis. These events led to significant electricity and gas price increases, directly affecting energy-intensive sectors such as tourism. Since Airbnb hosts are typically responsible for their energy costs, this crisis was expected to significantly influence their pricing strategies and revenues.

The main research question is: "What are the economic effects of the energy crisis on Airbnb listings in Madrid?". This question was further explored by addressing the following secondary research questions:

1. To what extent do changes in energy prices affect Airbnb rental prices?
2. How does the energy crisis impact the market demand for Airbnb listings?
3. Does the energy crisis influence the revenue of Airbnb listings?

In this study, we conducted a quantitative analysis using secondary data from Inside Airbnb, Kaggle, GitHub, and Eurostat. We created and analyzed a panel dataset of 3,272 unique Airbnb listings active from 2019 to 2024. By employing entity fixed-effects regression models, we assessed the impact of fluctuations in energy prices—a significant macroeconomic factor—on pricing, demand, and estimated revenues for these listings.

Results

Effect on rental prices

The results indicate that rising energy prices have a significant positive effect on Airbnb rental prices. Specifically, an increase in energy prices of €0.10 per kWh leads to an average nightly rental price increase of approximately €19.78. This effect is most pronounced for entire homes and apartments, as hosts typically bear the full responsibility for energy costs and tend to pass some of them onto their guests. In contrast, the impact on prices for private rooms is considerably less significant. This discrepancy can be attributed to lower energy consumption in private rooms, a greater sensitivity to price changes among guests in this segment, and potential differences in pricing strategies. An interaction analysis further confirms that price elasticity varies substantially by accommodation type.

Entire homes exhibit a significant response to increases in energy prices, whereas private rooms demonstrate a weaker adjustment in pricing. These observations highlight the structural differences in cost structures and pricing strategies among various accommodation types. Furthermore, they emphasize that the impact of energy price fluctuations on Airbnb rental prices is influenced by the type of accommodation being offered.

Effect on market demand

Market demand was estimated based on the number of nights booked, which was derived from the number of reviews per listing. The analysis revealed that, on average, an

increase of €0.10 per kWh is associated with approximately 9.75 fewer booked nights per year per listing. However, this effect did not remain constant over time. During the energy crisis (2021-2022), a temporary increase in demand was observed despite high energy prices. This surge in demand can be partly attributed to tourism recovery following the COVID-19 pandemic, which temporarily disrupted the relationship between energy prices and market demand.

A more detailed analysis of the periods confirmed that the sensitivity of demand to changes in energy prices was highly context-dependent. Before the energy crisis, there was a strong negative correlation. For every increase of €0.10 per kWh, there was an average decrease of 150 nights booked per listing. Positive interaction effects were observed during the crisis, likely due to the post-COVID recovery. After the crisis, an increase of €0.10 per kWh resulted in an average decrease of 9.5 nights booked annually.

Additionally, the results indicate structural differences in booking volume among various accommodation types. On average, private rooms are booked for 23 nights less per year than entire homes. This gap in market demand may be attributed to differences in target audiences, available amenities, and pricing strategies. The findings also suggest that rising energy prices negatively impact market demand for Airbnb stays. However, other contextual factors, such as the COVID-19 pandemic, significantly influence this effect.

Effect on revenues

Despite rising energy prices and a potential decrease in demand, the estimated annual revenues for hosts have increased. On average, a rise of €0.10 per kWh has been linked to an increase of €1,808 in annual revenue. This suggests that hosts cannot only pass higher energy costs onto their guests but, in some cases, even increase their profit margins. This could reflect the strategies employed by hosts who actively adjust their pricing or operate in markets with lower price sensitivity.

However, there's a notable distinction among different types of accommodation. The increase in revenue primarily benefited whole houses, while private rooms experienced a decline in earnings. This indicates varying levels of resilience to external cost increases, with not all accommodation types able to maintain or improve their revenue.

In summary, the energy crisis has significantly impacted the revenues of Airbnb hosts. Entire properties saw an increase in earnings, while private rooms faced a decrease.

Contribution of the Study

This study enhances our understanding of the sharing economy and examines how peer-to-peer rental markets respond to macroeconomic shocks. While previous research has primarily focused on internal pricing factors—location, size, and amenities—this study explicitly investigates external influences, more specifically, the impact of energy prices.

The findings are significant for various stakeholders within the tourism industry. These insights can help Airbnb hosts develop effective pricing strategies during crises. Policymakers can utilize this information to create targeted support measures for vulnerable market participants. Additionally, platform owners, like Airbnb, can gain a deeper understanding of market dynamics, which can inform adjustments to their recommendation algorithms. Ultimately, these results provide a solid foundation for future research in other cities and markets.

The study reveals that economic fluctuations impact different accommodations in varying ways. Hosts of entire homes are better positioned to implement price increases, while those offering private rooms tend to be more vulnerable to market changes.

Limitations and Considerations

While the study provides strong evidence of the impact of energy prices on Airbnb market indicators, there are some limitations to consider. First, the analysis is confined to Madrid due to the availability of historical data, affecting the findings' external validity. The behavior of Airbnb listings and hosts in other cities or countries may differ.

Additionally, the data on market demand was estimated indirectly through the number of reviews, which could introduce inaccuracies. Other macroeconomic factors, such as inflation, tourism policy, and COVID-19, influence price and demand dynamics. Although the models include control variables, it is impossible to isolate all contextual influences fully. For instance, fluctuations during the pandemic are challenging to attribute solely to energy prices.

For future research, it is advisable to extend the analysis to other cities and countries and to utilize more direct indicators of demand. Furthermore, conducting qualitative research on host strategies during crises could provide valuable insights into pricing and profit maximization decision-making processes.

Samenvatting

Doelstelling en Methodologie

Deze masterproef onderzoekt de invloed van de Europese energiecrisis, die in 2022 zijn piek bereikte, op de verhuurprijzen, de marktvraag en de opbrengsten van Airbnb listings — individuele aanbiedingen van woningen of kamers op het platform — in Madrid. Deze energiecrisis werd voornamelijk veroorzaakt door externe schokken, waaronder de COVID-19-pandemie en de Russische invasie van Oekraïne. Deze gebeurtenissen resulteerden in sterke stijgingen van de elektriciteits- en gasprijzen, met directe gevolgen voor energie-intensieve sectoren zoals toerisme. Aangezien Airbnb-hosts meestal zelf verantwoordelijk zijn voor hun energiekosten, werd verwacht dat deze crisis een grote impact zou hebben op hun prijsstrategieën en inkomsten.

De centrale onderzoeksvraag luidt: "Hoe heeft de energiecrisis de economische prestaties van Airbnb listings in Madrid beïnvloed?". Deze vraag werd verder uitgediept aan de hand van drie subvragen:

1. In welke mate beïnvloeden energieprijzen de verhuurprijzen?
2. Wat is de impact van energieprijzen op de marktvraag naar Airbnb listings, gemeten in aantal geboekte nachten?
3. Hoe beïnvloeden stijgende energieprijzen de geschatte opbrengsten van een listing?

Er werd een kwantitatieve analyse uitgevoerd op basis van secundaire gegevens van Inside Airbnb, Kaggle, GitHub en Eurostat. Een paneldataset van 3272 unieke Airbnb listings, actief tussen 2019 en 2024, werd gecreëerd en geanalyseerd met behulp van entity fixed-effects regressiemodellen. Door de combinatie van listinggegevens met energieprijsfluctuaties kon de invloed van deze macro-economische schok op prijszetting, vraag en geschatte opbrengsten worden geëvalueerd.

Resultaten

Effect op huurprijzen

De resultaten tonen aan dat stijgende energieprijzen een significante positieve invloed hebben op Airbnb-verhuurprijzen. Concreet leidt een stijging van de energieprijs met € 0,10/kWh tot een gemiddelde prijsstijging van ongeveer € 19,78 per nacht per listing. De stijging van verhuurprijzen als gevolg van toenemende energieprijzen is het meest uitgesproken bij gehele woningen en appartementen, waar verhuurders doorgaans volledig verantwoordelijk zijn voor de energiekosten en deze deels doorberekenen aan hun gasten. Bij privékamers is het effect op de prijzen aanzienlijk minder prominent. Dit verschil kan worden toegeschreven aan een lagere energieconsumptie in privékamers, een grotere prijsgevoeligheid van gasten in dit segment, en mogelijke verschillen in prijsstrategieën. Een interactie-analyse bevestigt bovendien dat de prijselasticiteit sterk varieert per type accommodatie. Gehele woningen vertonen een sterke reactie op energieprijsstijgingen, terwijl privékamers een zwakkere prijsaanpassing laten zien. Deze bevindingen duiden op structurele verschillen in kostenstructuur en prijsstrategie tussen de verschillende accommodatietypen en onderstrepen dat het effect van energieprijsfluctuaties op Airbnb-verhuurprijzen afhankelijk is van het type accommodatie.

Effect op marktvraag

De marktvraag werd geschat aan de hand van het aantal geboekte nachten, afgeleid van het aantal reviews per listing. De analyse toonde aan dat, in het algemeen, een stijging van €0,10/kWh leidt tot ongeveer 9,75 minder geboekte nachten per listing per jaar. Toch bleek dit effect niet constant doorheen de tijd. Tijdens de energiecrisis zelf (2021–2022) werd een tijdelijke stijging in de vraag waargenomen, ondanks hoge energieprijzen. Dit kan gedeeltelijk worden toegeschreven aan het herstel van het toerisme na de COVID-19-pandemie, wat een tijdelijk verstorend effect had op de relatie tussen energieprijzen en marktvraag.

Een meer gedetailleerde periode-analyse bevestigde dat de gevoeligheid van de vraag voor energieprijsveranderingen sterk afhankelijk was van de context. Voor de energiecrisis was er sprake van een sterke negatieve correlatie, waarbij een stijging van € 0,10/kWh gepaard ging met gemiddeld jaarlijks 150 minder geboekte nachten per listing. Tijdens de crisis werden positieve interactie-effecten waargenomen, vermoedelijk als gevolg van het post-COVID-herstel. Na de crisis resulteerde een stijging van € 0,10/kWh in een gemiddelde daling van 9,5 nachten per listing per jaar.

Daarnaast wijzen de resultaten op structurele verschillen in boekingsvolume tussen accommodatietypes. Privékamers worden gemiddeld 23 nachten per jaar minder geboekt dan gehele woningen. Deze structurele kloof in marktvraag kan samenhangen met verschillen in doelgroep, voorzieningen en prijsstrategieën. De resultaten tonen aan dat stijgende energieprijzen de marktvraag naar Airbnb-verblijven doorgaans negatief beinvloeden, al wordt dit effect sterk gemoduleerd door andere contextuele factoren zoals de COVID-19-pandemie.

Effect op opbrengsten

Ondanks de stijgende energieprijzen en mogelijke daling in vraag, zijn de geschatte jaarlijkse opbrengsten van verhuurders toegenomen. Een stijging van € 0,10/kWh ging gemiddeld gepaard met een toename van € 1808 in jaarlijkse opbrengst per listing. Dit wijst erop dat verhuurders erin slagen om hogere energiekosten niet alleen door te rekenen aan hun gasten, maar in sommige gevallen zelfs hun marges weten te verhogen. Mogelijk weerspiegelt dit het succes van hosts die actief prijsstrategieën toepassen of opereren in segmenten met een lagere prijsgevoeligheid.

Echter, er is een duidelijk onderscheid tussen accommodatiecategorieën. De stijging in opbrengst werd voornamelijk gedragen door gehele woningen. Voor privékamers daarentegen werd een daling in opbrengst vastgesteld. Dit wijst op een verschil in weerbaarheid tegenover externe kostenstijgingen, waarbij niet elk accommodatietype in staat blijkt om opbrengstenniveaus te behouden of te verbeteren.

Kortom, de energiecrisis heeft een duidelijke impact gehad op de opbrengsten van Airbnbs. Voor gehele woningen leidde dit tot een toename van de opbrengst, voor private kamers tot een afname.

Waarde van het onderzoek

Deze studie levert een belangrijke bijdrage aan het wetenschappelijk inzicht in de deeleconomie en de veerkracht van peer-to-peer verhuurmarkten tijdens macro-economische schokken. Waar eerder onderzoek zich richtte op interne prijsdeterminanten (zoals loca-

tie, grootte, faciliteiten), werd hier expliciet gekeken naar externe factoren zoals energieprijzen.

De onderzoeksresultaten zijn relevant voor verschillende belanghebbenden binnen de toeristische sector. Voor Airbnb-hosts helpen de bevindingen bij het formuleren van prijsstrategieën tijdens crisissituaties. Beleidsmakers kunnen deze inzichten benutten om gerichte steunmaatregelen te ontwikkelen voor kwetsbare actoren binnen de markt. Ook platformeigenaren, zoals Airbnb, kunnen baat hebben bij een beter begrip van de marktdynamiek, bijvoorbeeld om hun aanbevelingsalgoritmes aan te passen. Tot slot vormen de resultaten een waardevol uitgangspunt voor vervolgonderzoek in andere steden en markten.

Het onderzoek laat zien dat niet alle accommodatietypes op dezelfde manier worden beïnvloed door economische fluctuaties. Hosts van volledige woningen zijn beter gepositioneerd om prijsstijgingen te implementeren, terwijl aanbieders van private kamers kwetsbaarder zijn.

Kritische beschouwingen

Hoewel de studie sterke aanwijzingen biedt voor het effect van energieprijzen op Airbnb listings, zijn er enkele beperkingen. Ten eerste is de analyse beperkt tot Madrid vanwege de beschikbaarheid van historische gegevens. Dit beperkt de externe validiteit van de bevindingen. Airbnb listings en hosts in andere steden of landen zouden ander gedrag kunnen vertonen. Bovendien werd data over de marktvraag indirect geschat via het aantal reviews, wat onnauwkeurigheden kan opleveren.

Daarnaast spelen andere macro-economische factoren zoals inflatie, toerismebeleid en COVID-19 een rol in de evolutie van prijzen en vraag. Hoewel de modellen controlevariabelen bevatten, kunnen niet alle contextuele invloeden volledig geïsoleerd worden. De periode tijdens de pandemie vertoont bijvoorbeeld schommelingen die moeilijk louter aan energieprijzen kunnen worden toegeschreven.

Voor toekomstig onderzoek is het aan te raden om de analyse uit te breiden naar andere steden en landen, en gebruik te maken van meer directe vraagindicatoren. Ook kan kwalitatief onderzoek naar host-strategieën tijdens crisissen aanvullende inzichten bieden in de besluitvorming rond prijszetting en winstmaximalisatie.

Contents

1 Introduction

In 2022, an energy crisis emerged in the EU due to the pandemic and the Russian invasion of Ukraine. Gas and electricity prices rose significantly, while the energy supply decreased considerably (European Commission, 2022). In the second half of 2022, the average household electricity prices within the EU rose by nearly 21 percent compared to the same period in 2021 (Eurostat, 2023). Additionally, the average gas prices increased by over 46 percent compared to the corresponding period in 2021 (Eurostat, 2023). The likely explanation for this crisis is the significant reliance on oil and gas for production and consumption within the EU (Bjørnland, 2022). Consequently, this crisis disrupted multiple sectors, including households and energy-dependent industries (Cebotari & Paierele, 2024; Poutakidou & Menegaki, 2023).

Tourism was one of the most affected industries, as energy is essential for many hospitality operations due to the heating, cooling, and other electricity needs in accommodations and services (Poutakidou & Menegaki, 2023). The accommodation industry plays a central role in this sector, accounting for roughly 20% of tourism-related businesses in the EU (Weston et al., 2019). One significant aspect of this industry is the sharing economy, with platforms like Airbnb capturing considerable market share in recent years (Gyódi & Nawaro, 2021).

Airbnb is a peer-to-peer platform, where individuals can list and rent short-term accommodations (Fang et al., 2016; Gyódi, 2019). Unlike traditional hotels, which often benefit from centralized cost management and long-term contracts with utility providers, Airbnb hosts are usually private individuals who directly bear the burden of operational costs, such as energy expenses (Barak, 2022). Nevertheless, tenants can often find more affordable lodging on Airbnb than hotels in most urban areas (Fang et al., 2016). According to Guttentag (2015), these relatively low prices exist because the host's main costs, such as rent or mortgage and utility bills, are typically already covered by their personal living expenses. In addition, hosts usually have minimal or no labor expenses and do not rely entirely on the income generated from renting out their property. Nevertheless, rental prices directly affect guests' lodging preferences and hosts' profitability, making the price a critical factor on Airbnb (Zhang et al., 2017).

Given the importance of pricing, hosts encountered major difficulties as soaring energy costs made it increasingly challenging to sustain their short-term rentals (Barak, 2022). Hosts may raise their nightly rates to cover increased costs, as rising energy prices can result in higher prices for other products or services (Cebotari & Paierele, 2024). However, this strategy risks reducing booking volumes, as listings with higher prices typically receive fewer bookings (Deboosere et al., 2019). On the other hand, avoiding price increases can lead to reduced profit margins, making hosting less sustainable over the long term.

Madrid provides a particularly relevant setting to study these effects, as it is Spain's second most popular tourist destination (European Commision, 2024). Additionally, historical data on Airbnb listings in Madrid is easily accessible online for the relevant periods, and reliable energy price data can be obtained from Eurostat (Eurostat, 2023; InsideAirbnb, 2024). These data sources enable a comprehensive analysis of the relationship between energy prices and Airbnb listings.

While existing literature provides extensive insights into the internal factors affecting Airbnb pricing, such as listing attributes, location, and seasonal factors (Sainaghi, 2021), there is a lack of research on how external macroeconomic shocks impact pricing and

demand. Some studies have shown that political uncertainty and pandemics can significantly affect booking behavior and revenue in the short-term rental market (Benítez-Aurioles, 2019; Cheng et al., 2023). However, the impact of energy price volatility remains largely unexplored.

This research aims to address this significant gap by analyzing the impact of the European energy crisis on Airbnb listing prices, booking demand, and estimated revenue in Madrid. The study utilizes a panel dataset of more than 3,000 Airbnb listings from 2019 to 2024, which has been combined with official energy price data from Eurostat. By employing entity fixed-effects regression models, the analysis seeks to isolate the influence of energy prices while controlling for the time-invariant characteristics of each listing.

This research contributes to the existing literature on economic resilience in the tourism sector, especially within decentralized, peer-to-peer markets like Airbnb. The study offers practical insights for hosts and policymakers along with its theoretical contributions. It demonstrates how energy shocks can be absorbed or reflected in pricing strategies.

The remainder of this study is structured as follows: Section 2 presents a literature review on the main determinants of Airbnb listing prices. Section 3 outlines the primary and secondary research questions, specifies the research objectives, and describes the expected benefits of conducting this study. Section 4 details the methodological approach, including the data collection strategy, data preparation, descriptive analyses, and the empirical strategy. Section 5 presents the findings of the regression models evaluating the effect of energy prices on Airbnb prices, demand, and revenue. Section 6 provides a discussion of the results, emphasizing theoretical and practical implications while acknowledging the limitations of the study. Section 7 concludes with a comprehensive summary of the principal findings and provides recommendations for future research directions.

2 Literature Review of Airbnb Price Mechanism

Many studies have attempted to identify and explain the key factors determining Airbnb listing prices. These factors range from listing attributes to location and destination characteristics. According to Ye et al. (2018), determining the price of an Airbnb listing is quite challenging, as each listing provides unique value to its guests. However, this section will review and discuss the main findings from the existing literature, emphasizing the primary drivers that influence pricing in the Airbnb market.

The accommodation price is a crucial factor in hospitality industries, such as Airbnb (Zhang et al., 2017). Understanding the elements that influence pricing is highly beneficial, as it enables hosts to set a fair price that benefits both themselves and their guests within the sharing economy (Zhang et al., 2017).

In the sharing economy, two different pricing models exist. Some platforms like Uber and Lyft use algorithms to set prices for the individual service providers. In the case of Uber, the platform decides on the price at which a driver (the service provider) is offering their services. Other platforms like Airbnb provide a reference price but allow service providers (hosts) to set their own prices (Kwok & Xie, 2019). Airbnb uses dynamic pricing algorithms to provide price suggestions such as ”Price Tips” and ”Smart pricing” (Ye et al., 2018). However, hosts tend to incorporate price suggestions to some extent but generally opt for higher prices (Ye et al., 2018).

We used the framework of Sainaghi (2021) as a guideline for structuring this literature

review. The authors carried out a state-of-the-art review of the price determinants of an Airbnb listing. Sainaghi (2021) analyzed 33 relatable articles and identified six categories of determinants: listing attributes, host characteristics, guest reviews, location attributes, destination variables, and external comparisons. Each category has subcategories that consider a more specific group of variables. Table 1 provides an overview of the determinants, including whether this study uses a particular variable.

Table 1: Overview of Airbnb price determinants based on Sainaghi (2021) and their inclusion in this study

Category	**Subcategories**	**Included in this study**
Listing attributes	Amenities, contractual terms, rules, and size	Yes - room type, number of guests (accommodates)
Host characteristics	Superhost status, identity verification, response rate	No – not included explicitly, because the study focuses on listing level and assumed to be controlled for via listing fixed effects
Guest reviews	Review rating, number of reviews	Yes - the number of reviews was used to estimate bookings (not included as an explanatory variable)
Location attributes	Location accessibility, environmental factors, social and economic variables	No – not modeled directly, but mostly captured by listing fixed effects
Destination variables	Competition, seasonality, and type	No - not included due to data limitations (yearly data)
External comparisons	Comparisons between cities	No – not included due to data limitations

The *listing attributes* consist of four subgroups: amenities, contractual terms, rules, and size. Listing amenities show a strong positive correlation with the price. Examples include free parking, a real bed, Wi-Fi, a balcony, a pool, a gym, heating, and air conditioning. Wi-Fi and free parking significantly increase the listing price, while offering breakfast negatively impacts the price (Wang & Nicolau, 2017). Furthermore, having a gym or a pool positively influences property prices, indicating that listings with these amenities are generally priced higher (Gibbs, Guttentag, Gretzel, Morton, & Goodwill, 2018). Additionally, a listing with a doorman charges a higher price (Cai et al., 2019). These results show that amenities can strongly influence the market price, and consumers' valuations are primarily determined by the functionalities and amenities of an Airbnb listing (Chen & Xie, 2017). Contractual terms include the cancellation policy, cleaning fee, extra guest price, security deposit fee, and self-check-in. Flexible cancellation policies increase the customer valuation of a property, though it is linked with lower listing prices (Chen & Xie, 2017). This confirms other findings, which indicate that strict cancellation policies lead to higher prices (Cai et al., 2019; Perez-Sanchez et al., 2018; Wang & Nicolau, 2017). However, Perez-Sanchez et al. (2018) found that the influence of stricter cancellation policies decreases for higher-priced listings. On the other hand, instant booking has a

negative effect on the price. Hosts aiming for high occupancy often attract more guests by reducing their prices and offering instant booking options to increase reservations (Gibbs, Guttentag, Gretzel, Morton, & Goodwill, 2018; Wang & Nicolau, 2017). While the cleaning fee and extra guest fee do positively influence a listing's price, their impact remains limited (Camatti et al., 2024). The listing rules address policies regarding smoking and pets. Allowing smoking significantly negatively impacts the price of lodging (Chattopadhyay & Mitra, 2019; Wang & Nicolau, 2017). Besides, allowing pets also has a significant negative impact on the price (Chica-Olmo et al., 2020). The listing size is a crucial determinant of the price (Gyódi & Nawaro, 2021; Sainaghi, 2021). Accommodation types such as houses, villas, and chalets are generally priced 8 percent higher than accommodations such as apartments, lofts, and bed & breakfasts (Wang & Nicolau, 2017). If the listing is an entire house/apartment, it is more expensive compared to private or shared rooms (Chen & Xie, 2017; Gibbs, Guttentag, Gretzel, Morton, & Goodwill, 2018; Wang & Nicolau, 2017). This is also the case in major European cities such as Barcelona and Paris (Gyódi & Nawaro, 2021). According to Perez-Sanchez et al. (2018), the price of an entire house/apartment increases by 75 percent compared to a single room. Properties with extra bathrooms and bedrooms, as well as real beds, are typically priced higher (Chen & Xie, 2017; Gibbs, Guttentag, Gretzel, Morton, & Goodwill, 2018; Perez-Sanchez et al., 2018; Wang & Nicolau, 2017). In major European cities, adding one bedroom can increase the price by 6.6 to 26.6 percent, depending on the city (Gyódi & Nawaro, 2021). Supporting these findings, Wang and Nicolau (2017) notes that, on average, adding one more bedroom leads to a price increase of 12.4 percent. Besides, an additional bathroom positively impacts the price by almost 11 percent. Moreover, the person capacity of a listing correlates positively to the number of bedrooms of an Airbnb, indicating a positive influence on the price as well (Gyódi & Nawaro, 2021). This finding is confirmed by other studies (Gibbs, Guttentag, Gretzel, Morton, & Goodwill, 2018; Perez-Sanchez et al., 2018; Wang & Nicolau, 2017). Additionally, these attributes can lead to higher revenue generated by the listing (Kwok & Xie, 2019).

Host characteristics are critical price determinants and mainly positively influence the price of a listing (Sainaghi, 2021). Being a superhost consistently leads to higher prices (Wang & Nicolau, 2017). Other studies confirm these findings (Gibbs, Guttentag, Gretzel, Morton, & Goodwill, 2018; Gyódi & Nawaro, 2021). However, Chen and Xie (2017) did not find a significant impact of a super host status on consumer valuation. Moreover, hosts providing any identity verification may charge higher prices as well (Wang & Nicolau, 2017). According to Chen and Xie (2017), consumers are willing to pay more for a listing that offers multiple host verification options. The response rate of a host positively influences the listing price, but the effect on the price is relatively small (Camatti et al., 2024).

Guest reviews concern the review ratings and the number of reviews. Lawani et al. (2019) highlights the importance of customer reviews. They provide insights into the inherent quality of hosts and, consequently, influence demand on the Airbnb platform. These reviews impact not only the host's pricing but also the prices of neighboring hosts. The results show that an increase of one point in the review score will result in a 1.4 percent rise in room prices. Deboosere et al. (2019) demonstrated that the price increases by more than 8 percent when the listing receives one additional star in average rating. Other studies confirm that rating scores positively impact the listing price (Cai et al., 2019; Chen & Xie, 2017; Wang & Nicolau, 2017). On the contrary, Zhang et al. (2017) found a negative correlation between the rating score and the price. The annual num-

ber of reviews negatively impacts rental prices, as lower-priced listings generally receive more bookings and, consequently, more reviews (Deboosere et al., 2019; Gibbs, Guttentag, Gretzel, Morton, & Goodwill, 2018; Lawani et al., 2019; Wang & Nicolau, 2017). However, Airbnb claims that the number of reviews significantly influences pricing (Hill, 2015). Camatti et al. (2024) argues that ratings and reviews have a limited influence on pricing.

Location attributes are divided into location accessibility, environmental factors, and social and economic variables. Location accessibility refers to the distance to the city center, convention centers, transportation, and other points of interest. The accommodation price tends to decrease as its distance from the city center increases (Chica-Olmo et al., 2020; Gyódi & Nawaro, 2021; Wang & Nicolau, 2017). This relationship also applies to convention centers (Zhang et al., 2017), coastlines (Perez-Sanchez et al., 2018), tourism attractions (Cai et al., 2019), and points of interest (Chica-Olmo et al., 2020). Furthermore, the farther an accommodation is from a metro station, the lower its price, but this varies across different cities (Gyódi & Nawaro, 2021). The findings of Deboosere et al. (2019) revealed that the opposite regarding proximity to subway or metro stations is true. Lawani et al. (2019) found no influence of the distance to the nearest train station on listing prices. These latter results indicate that Airbnb guests primarily value how well public transit connects them to key destinations, not the proximity of the transit itself (Deboosere et al., 2019). Noise negatively impacts listing prices, as guests prefer quiet areas (Chica-Olmo et al., 2020). Moreover, social and economic factors play a moderate role in determining the price of an Airbnb. Listings in higher income areas are generally priced higher (Deboosere et al., 2019; Moreno-Izquierdo et al., 2019). Furthermore, neighborhoods with higher education levels increase house demand, positively impacting Airbnb prices (Lawani et al., 2019). However, the population size negatively affects listing prices, possibly due to higher-quality accommodations in smaller destinations (Moreno-Izquierdo et al., 2019). Additionally, properties located in areas with higher unemployment rates are generally priced lower (Ribes et al., 2018).

Destination consists of three more specific groups: competition, seasonality, and type. Destination competition mostly does not have a significant impact, but when they are substantial, they are positive (Sainaghi, 2021). Examples include Airbnb listings and the number of hotels in the same area. Other variables include reviews, ratings, and competitors' prices. Chen and Xie (2017) found that the number of hotels in a given area negatively affects Airbnb prices. This indicates that consumers value Airbnb listings less when more hotels are active in the same area. Whenever the average price of hotels increases, hosts tend to increase their prices (Voltes-Dorta & Inchausti-Sintes, 2021). Deboosere et al. (2019) emphasizes that more Airbnb listings in the same area increase prices, as attractive areas are more likely to see future growth in the number of listings. However, Voltes-Dorta and Inchausti-Sintes (2021) found conflicting results, indicating that an increase in supply leads to lower prices due to stronger competition in the local market. On the other hand, a higher market demand leads to higher listing prices (Lawani et al., 2019; Magno et al., 2018). Deboosere et al. (2019) stresses that seasonality factors affect accommodation prices. Hosts often increase their prices during the summer to match seasonal demand patterns. Casamatta et al. (2022) confirms the impact of seasonality on listing prices. The months of June, July, August, and September significantly affect Airbnb prices, demonstrating that the peak season greatly influences rates (Casamatta et al., 2022). The same property is 19.8 percent more expensive in June compared to January. The prices rose even further in July and August, reaching 48.1

percent and 54.3 percent higher than in January, respectively (Casamatta et al., 2022). Considering the destination type, accommodations close to ski areas or the old town are significantly more expensive (Falk et al., 2019). However, the property characteristics are much more relevant in determining the price of a listing (Falk et al., 2019).

External comparisons are usually comparisons between cities based on revenue generated by the listings (Sainaghi, 2021). However, this group is not directly linked to the price determinants of Airbnb listings.

In summary, the listing type and size have the most considerable effect on the price (Sainaghi et al., 2021; Tang et al., 2024). Accommodations like houses and villas tend to be more expensive than apartments and lofts. Renting an entire apartment or house significantly raises the price compared to private or shared rooms. Besides, the higher the capacity of a listing, the higher the price (Tang et al., 2024). Location and seasonality seem to have a large effect as well. Whenever a listing is farther from the city center, the price decreases. During summer, which is peak season, prices are typically higher. Furthermore, the provision of most listing amenities positively influences the price. Host characteristics such as being a superhost, having a verified identity, and having a high response rate usually push the price upwards. Listings with high customer ratings tend to be more expensive, but lower-priced listings generally have more reviews. Lastly, competitors can influence prices as well, based on the characteristics of the local market.

2.1 Justification of the Research

To understand the significance of Airbnb in the broader tourism sector, Figure 1 illustrates the changes in the number of nights spent in various tourist accommodations in Europe from 2018 to 2024. The category of short-term rental (STR) platforms, which includes Airbnb, Booking.com, Expedia, and Tripadvisor, has experienced consistent growth (Eurostat, n.d.-c). In 2024, bookings on these platforms reached an all-time high of 854 million guest nights, reflecting an 18.8% rise compared to 2023 (Eurostat, n.d.-c).

Hotels hold a significant portion of total guest nights in Europe, indicating that traditional accommodations still dominate in absolute numbers. However, short-term rental (STR) platforms have experienced consistent growth in recent years. They align with the tourism sector's overall recovery, especially in the post-pandemic period. This trend shows that platforms like Airbnb are becoming increasingly integrated into mainstream travel behaviors and have established themselves as a stable component in the European accommodation sector.

According to Statista (2025), Airbnb has the second-largest market capitalization among global travel and tourism platforms, highlighting its importance. It indicates that Airbnb is a major player in the STR segment and justifies its relevance as a case study when analyzing the effects of macroeconomic shocks such as the energy crisis on the tourism market.

As mentioned in the introduction, the ongoing energy crisis in Europe has created unprecedented challenges for various industries, including hospitality. Fluctuating energy prices heavily impact costs such as utilities and maintenance. Moreover, the demand for tourist accommodation decreases as gas prices increase (Poutakidou & Menegaki, 2023). This could influence the profitability of an Airbnb listing. Therefore, hosts might increase prices. Additionally, as listing size is an essential factor in determining an Airbnb's price, the energy price shock might also have a stronger effect on more extensive listings. While there is a growing body of research examining the effects of energy crises on macroe-

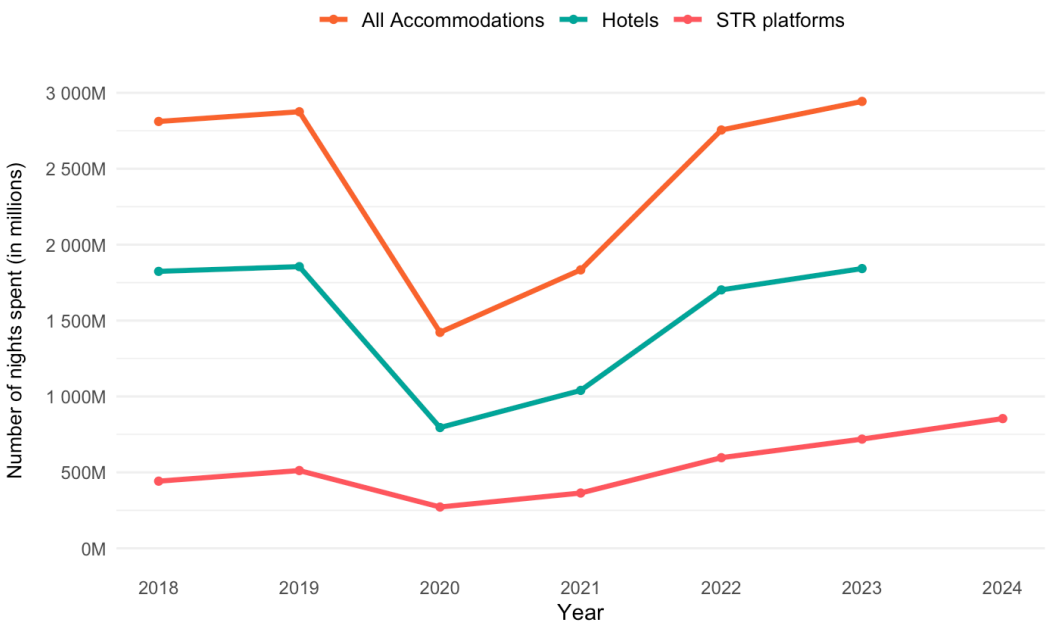


Figure 1: Evolution of nights spent in European tourist accommodations, by category from 2018 to 2024 (Source: Eurostat, n.d.-a, n.d.-b). *Note: Data for 2024 is only available for STR platforms, data for hotels and all accommodations is missing.*

conomic factors and energy policy adjustments (Bjørnland, 2022; Cebotari & Paierele, 2024; Edelstein & Kilian, 2009; Hu, 2021; Parag et al., 2023), there is still a significant gap in understanding how these crises influence the hospitality sector, particularly Airbnb owners.

This research aims to fill the gap by quantitatively exploring how the energy crisis impacts Airbnb listings. As a major competitor in the accommodation sector, Airbnb presents unique challenges for understanding market dynamics due to its decentralized pricing strategies, varying operational costs for hosts, and differing consumer demand.

The existing literature on Airbnb primarily focuses on pricing determinants. However, little attention has been given to the influence of external economic shocks, such as the energy crisis, on Airbnb listing prices, market demand, and revenue. For instance, Benítez-Aurioles (2019) highlights that hosts adjust prices in response to external shocks, such as terrorism and political uncertainty, as these events drive a decline in demand. Cheng et al. (2023) showed that the COVID-19 outbreak significantly reduced Airbnb booking activity. Building on this perspective, this research seeks to fill the gap by exploring the effect of the recent energy crisis on Airbnb listings in Madrid.

This research aims to provide theoretical and practical insights into how energy volatility affects the peer-to-peer accommodation industry. Specifically, it will examine how the Airbnb market in Madrid is affected by the increasing energy prices. By exploring these factors, the study seeks to contribute to the development of adaptive and sustainable strategies for the hospitality sector, ensuring resilience in the face of current and future economic challenges.

3 Research Questions

3.1 Primary Research Question

The ongoing energy crisis has significantly influenced the hospitality sector. However, its impact on short-term rental prices, particularly on platforms such as Airbnb, remains insufficiently examined within existing literature. Consequently, the main research question we aim to answer in this study is:

”What are the economic effects of the energy crisis on Airbnb listings in Madrid?”

3.2 Secondary Research Questions

To further explore the main research question, several secondary research questions have been formulated. By addressing these secondary questions, the research offers a more detailed and nuanced understanding of how energy prices influence short-term rental markets, allowing for a comprehensive analysis that goes beyond the primary question.

The first question is related to the price of Airbnb listings: ”To what extent do changes in energy prices affect Airbnb rental prices?”. It examines the direct relationship between fluctuations in energy prices and the pricing strategies of Airbnb hosts.

The second question pertains to market demand: ”How does the energy crisis impact the market demand for Airbnb listings?” This question investigates how the broader economic effects of the energy crisis, such as rising living costs and reduced budgets, affect consumer demand for short-term rentals.

The third question examines how changes in energy prices may affect the revenue of Airbnb listings: ”Does the energy crisis influence the revenue of Airbnb listings?” This question explores the financial impact of rising energy prices on the earnings of Airbnb hosts.

3.3 Objectives

The primary objective of this research is to analyze the impact of the energy crisis on Airbnb rental prices in Madrid. Specifically, the study aims to examine the relationship between fluctuations in energy prices and Airbnb pricing. Furthermore, this study offers insights into how fluctuations in energy prices and pricing adjustments impact estimated revenue and demand. Moreover, this study will contribute to the effect of macroeconomic changes on short-term rentals. The upcoming subsection will outline the expected benefits of conducting this research.

3.4 Expected Benefits

Firstly, the research will provide insights into how Airbnb prices change in response to energy price increases. More specifically, to determine whether energy costs, which are a significant operational expense, are reflected in rental prices and to what extent hosts adjust their rates in response to changes in energy prices.

Secondly, the research will identify how the energy crisis has affected Airbnb listings, including its impact on demand and profitability. This study will provide insights into whether higher energy prices decrease the number of bookings or alter guest behavior on platforms like Airbnb. Moreover, the research aims to determine whether listings

experience a decline in revenue due to reduced demand or if they can mitigate the effects of higher energy costs by increasing their rental prices.

Thirdly, the research will contribute to the literature on the impact of external economic shocks, offering new perspectives on how the energy crisis affects Airbnb operations. Understanding these dynamics is crucial for evaluating the overall economic sustainability of Airbnb listings during the energy crisis.

4 Methodology

This study employs a quantitative research design to examine the effect of energy prices on Airbnb listing prices in Madrid. The analysis is based on secondary data from two primary sources: Inside Airbnb, which provides publicly available listing-level data on short-term rentals, and Eurostat's official energy price statistics for Spain. The following sections detail the data collection process, preparation steps, and the empirical strategy used for the analysis.

4.1 Data Collection Strategy

Airbnb listing data was obtained through external sources such as Inside Airbnb and Kaggle, specifically covering listings in Madrid. For this research, we selected Madrid as the main city of focus. This city was chosen mainly because it is the only city where we can find extensive historical Airbnb data, including data from the energy crisis period. Moreover, Madrid is the second most popular tourist destination in Spain (European Commision, 2024).

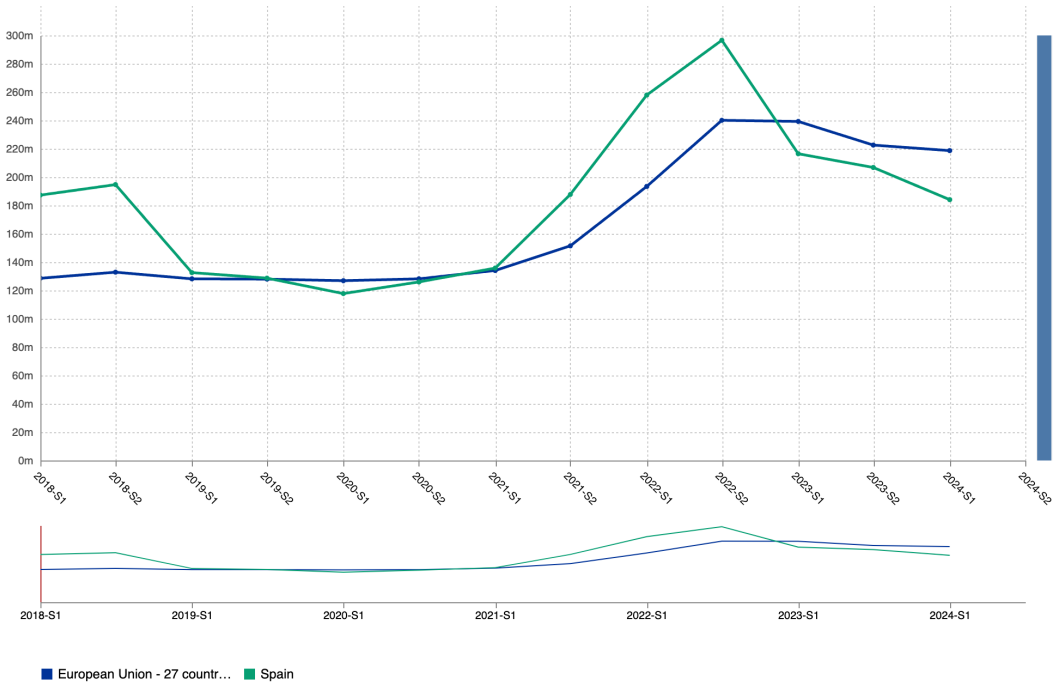
Since InsideAirbnb only provides publicly available data for one preceding year, additional historical data were collected from Kaggle for 2019 (Kerneler, 2020), 2020, and 2021 ("Madrid Airbnb Data," 2021) and from Github for 2022 (Stefania Dinica, 2022).

Secondary data on energy prices were sourced from Eurostat (Eurostat, 2024a, 2024b). This data includes electricity and gas price fluctuations in Spain. Figure 2a and 2b show the semesterly evolution of electricity and gas prices across all EU countries, including the individual evolution of Spain. In Spain, electricity and gas prices peaked at a higher level than the average energy prices in EU countries.

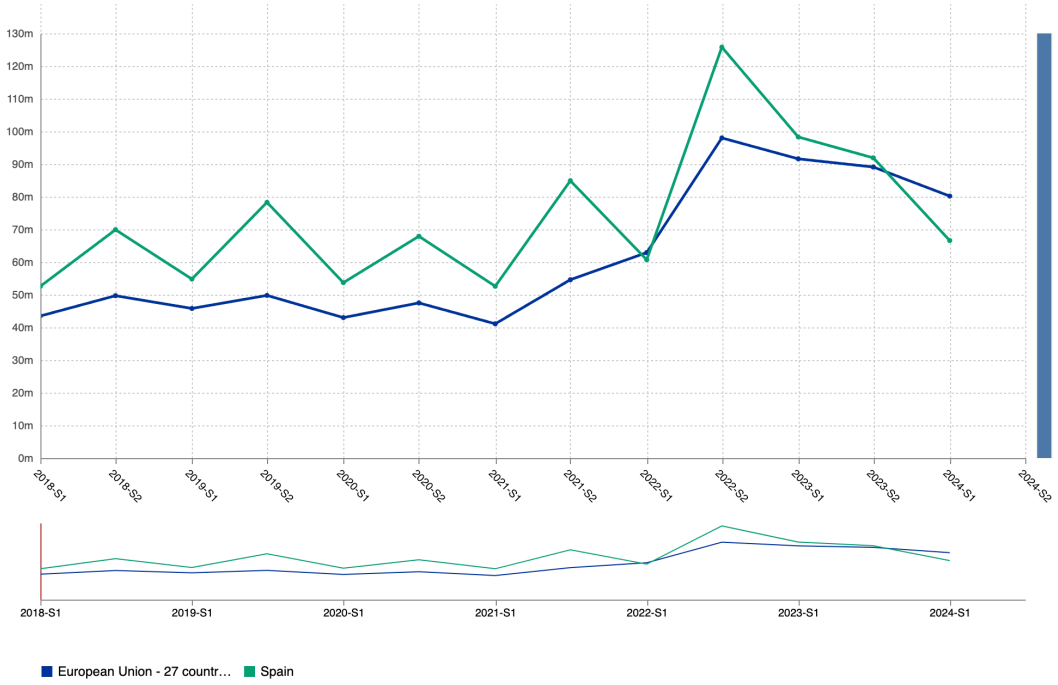
4.2 Data Preparation

To effectively analyze the impact of the energy crisis, we focus exclusively on active Airbnb listings before, during, and after the shock. We will examine three distinct periods. The first period spans from 2019 to 2020, representing the time before the shock in energy prices. The second period runs from 2021 to 2022, during which energy prices increased significantly and reached an all-time high in Spain (Eurostat, 2023). The final period begins in 2023 and continues until 2024. We will use this last period to assess the long-term effects of rising energy prices on the Airbnb market.

We used the first and last review variables to identify which listings received their first review before the initial period and their last review after the final period. This approach ensures that these listings were active throughout all periods and that they hosted guests multiple times. Madrid has 3,570 active listings over this period.



(a) Evolution of electricity prices for household consumers



(b) Evolution of gas prices for household consumers

Figure 2: Evolution of electricity and gas prices in Spain and the Euro area (Source: Eurostat, 2024a, 2024b)

4.2.1 Panel Construction and Missing Values

We combined data from all periods into one panel data frame, ensuring every listing had an entry for each year. For some listings, missing values were identified. However, we used a down-up approach to fill in missing fixed variables. This method first fills the current missing value with the value of the previous entry. Otherwise, it is filled with the value of the following entry of that listing ("Fill in missing values with previous or next value — fill," n.d.). These fixed variables include host ID, room type, accommodates, minimum and maximum nights, and first review.

4.2.2 Room Type Reclassification

The original dataset comprised four room types defined by Airbnb: entire home/apartment, private room, hotel room, and shared room. However, hotel and shared room listings represented less than 1% of the total sample. These categories were merged to avoid sparsity in the categorical levels, following Airbnb's documentation ("Types of places to stay - Airbnb Help Center," n.d.).

Specifically, shared and hotel rooms were combined with private rooms, as they share some common characteristics. Shared rooms are accommodations where guests share a space with others, including sleeping areas. Private rooms also involve shared common areas but provide a private sleeping space. Hotel rooms can offer private and shared options, typically providing amenities similar to those in private rooms, such as access to communal spaces. Hence, from the perspective of guest experience and privacy level, shared rooms and hotel rooms are more closely aligned with private rooms than with entire homes or apartments.

Additionally, this recategorization improves the interpretability and robustness of the regression model by including room type as a categorical factor. Comparing underrepresented categories to more dominant categories, such as hotel rooms, may result in unreliable or misleading coefficient estimates.

4.2.3 Handling Extreme Values in Stay Duration Variables

We identified several extreme values for the variable "minimum nights", such as values exceeding 365 nights, which are unlikely to represent actual booking policies. To address this issue, we replaced all values above 365 with NA. We applied the same approach for "maximum nights", replacing values exceeding 1,825 (equivalent to five years) with NA. These missing values were subsequently imputed using the down-up filling strategy described earlier. Nonetheless, this method does not ensure that all extreme values are removed.

As a result, we applied winsorization to the minimum nights variable to reduce the influence of extreme but plausible values. Specifically, values that fell below the 1st percentile or above the 99th percentile were replaced with their respective threshold values. The distribution of the maximum nights variable showed no outliers after the first cleaning step.

4.2.4 Price Outlier Handling

We implemented a two-step outlier detection approach based on the interquartile range (IQR) method and relative deviation from a listing's typical pricing to detect suspicious

price entries. The IQR method identifies outliers by flagging values that exceed the upper bound, calculated as the third quartile (Q3) plus 1.5 times the interquartile range (Q3 + 1.5 × IQR). While this method effectively captures general outliers across the dataset, it does not account for listing-specific pricing patterns.

To address this, we introduced an additional condition: the price of a listing was only flagged as suspicious if its price per person exceeded the IQR upper bound and deviated by more than 500% from the listing's historical median price per person over all available years. Based on exploratory data analysis, the 500% threshold was selected, which revealed that values beyond this level typically resulted from data entry errors, such as missing decimal points or misreported currencies, rather than legitimate market behavior. Lower thresholds, such as 200% or 300% led to excessive flagging of valid high-end listings, including luxury accommodations.

This dual-criterion approach allowed us to isolate erroneous values while preserving legitimate price variation effectively. The incorrect price of all flagged entries was replaced with missing values (NA) to avoid skewing the analysis. We replaced a total of 62 suspicious entries with NA values.

Moreover, we only retained listings with valid price entries for each of the three periods: before, during, and after the energy crisis. This ensures that each listing provides sufficient data for a consistent and meaningful analysis.

Additionally, we excluded one particular case that, although not flagged, raised our suspicions. This case involved a nightly price of over €5,500 in 2021 and 2022. However, the price for a night was approximately €100 in the years before and after. After these preparation steps, we retained a total of 3,272 unique listings in our dataset. The panel dataset includes a total of 19,632 entries, with 793 missing price values.

4.3 Descriptive Analysis

4.3.1 General Characteristics of the Listings

Table 2 provides a brief overview of the summary statistics of listings in Madrid. The dataset includes 3,272 unique Airbnb listings active before, during, and after the energy crisis. The average listing has a nightly price of 100.66 euros, accommodates roughly 4 guests, and is available for around 178 days per year.

Table 2: Summary statistics of Airbnb listings in Madrid

Variable Name	Min	Q1	Mean	Q3	Max	SD
Price	9.00	53.00	100.66	120.00	1289.00	82.37
Accommodates	1.00	2.00	3.73	4.00	20.00	2.18
Total reviews	0.00	34.00	119.21	167.00	1060.00	118.18
Reviews (LTM)	0.00	5.00	24.40	38.00	192.00	24.09
Reviews/month	0.01	0.85	2.23	3.19	17.05	1.75
Minimum nights	1.00	1.00	3.40	3.00	30.00	5.07
Maximum nights	1.00	90.00	726.53	1125.00	1825.00	491.98
Availability (365)	0.00	69.00	178.11	298.00	365.00	122.27

Table 3 displays the distribution of room types for Airbnb listings in Madrid in 2024.

The majority of these listings are entire homes or apartments, comprising 78.94% of the total. Private rooms follow at 21.06%. This highlights a strong presence of entire accommodations, compared to private room options in the Madrid Airbnb market.

Table 3: Room type distribution of Airbnb listings in Madrid in 2024

Room Type	Count	Share
Entire home/apartment	2,583	78.94%
Private room	689	21.06%

4.3.2 Price-related Statistics

Figure 3 illustrates the price distribution across the dataset over all observed periods. The listing prices exhibit a right skew, with a substantial concentration of listings priced under €150 and a prominent peak around €100. This pattern suggests that the majority of Airbnb listings in the dataset are relatively affordable, while a smaller proportion are considerably more expensive, resulting in a long tail on the right side of the distribution. However, it is not immediately apparent from the figure that there are indeed listings with nightly rates exceeding €500.

Figure 3: Price distribution in Madrid over all periods

Figure 4 illustrates the annual trends in average Airbnb listing prices in Madrid alongside the average energy price, which was calculated as the mean of electricity and gas prices, from 2019 to 2024. The graph shows a diverging pattern between these variables, particularly during the European energy crisis.

From 2021 to 2022, average energy prices experienced a significant surge, increasing from approximately €0.115 to over €0.185 per kWh, marking the peak of the energy

crisis. In contrast, average listing prices during this period rose more gradually, climbing from around €83 in 2021 to roughly €100 in 2022.

Notably, while energy prices began to decline after 2022, average Airbnb prices continued to rise steadily, reaching their peak of approximately €135 by 2024. This pattern suggests that the impact of the energy crisis on listing prices may be delayed or influenced by other factors such as inflation or the recovery of post-pandemic tourism.

These dynamics indicate that although energy prices likely affected operational costs, Airbnb prices did not follow the same trajectory immediately, reflecting a complex relationship between energy prices and Airbnb listing prices.

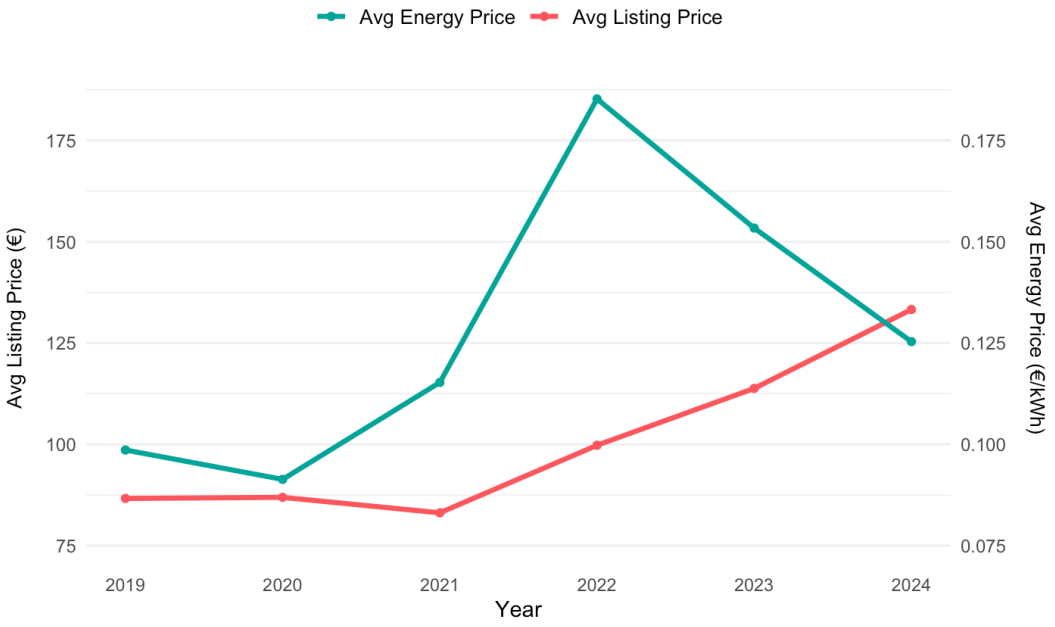


Figure 4: Evolution of average energy and listing prices over the years

4.3.3 Market Demand Statistics

In this research, the number of nights booked in the last twelve months determines the market demand for a listing. The estimated number of nights booked over the previous twelve months equals the average length of stay multiplied by the number of reviews LTM and divided by the review rate. Since Airbnb has not released any official statement regarding the average length of stay in Madrid, we assumed it to be 3 nights, following Inside Airbnb's assumption (InsideAirbnb, 2024). Moreover, we used a review rate of 50% as recommended by Inside Airbnb's occupancy model (InsideAirbnb, 2024).

Figure 5 shows the evolution of the market demand over time in Madrid for Airbnb listings. This figure indicates a significant decline in 2021, with demand dropping to roughly 35 nights per listing. This low point coincided with the peak of the COVID-19 pandemic, when international travel restrictions and public health concerns severely disrupted tourism activity, more specifically booking activity in 2020 (Cheng et al., 2023). The observed decline in demand during 2021 can be explained by considering that this demand is a direct reflection of the number of nights booked in the preceding year, specifically 2020.

Beginning in 2022, the Airbnb market in Madrid saw a robust recovery, with the average number of nights booked increasing steadily and exceeding pre-pandemic levels by 2023, ultimately peaking in 2024 at approximately 170 nights. This resurgence could be explained by lifted travel restrictions and the rise of international visitors (European Commision, 2024).

Nonetheless, this recovery occurred against a backdrop of greater macroeconomic instability, especially during the European energy crisis that reached its height in 2022 (see figures 2a and 2b). Demand has shown remarkable resilience despite rising operational costs for hosts, such as heating and electricity. One possible explanation for this trend is that higher listing prices may have partially transferred the increase in energy costs to guests. Moreover, higher market demand leads to increased listing prices (Lawani et al., 2019; Magno et al., 2018). Therefore, we assume that market demand and listing prices are positively correlated, which is crucial to consider further in this study.

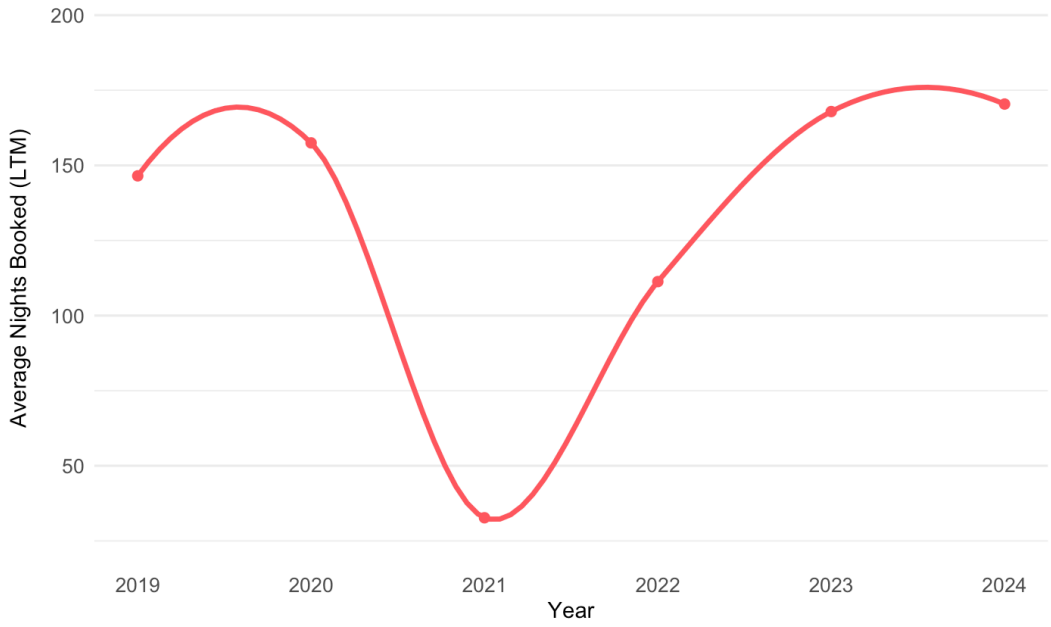


Figure 5: Average market demand in Madrid over time

4.3.4 Revenue Statistics

Figure 6 illustrates the trend in average revenue for Airbnb listings in Madrid from 2019 to 2024. The decline observed in 2021 corresponds with a drop in demand, as previously noted due to COVID-19. However, the significant revenue growth starting in 2022 appears to be driven more by rising prices than by increased bookings.

In 2024, revenue appears to be increasing faster than market demand, suggesting that rising prices primarily drive this revenue growth. In Figure 5, market demand stagnated from 2023 to 2024. However, revenue continued to increase significantly, reaching an average of around €22,500 in 2024, suggesting hosts may have raised their nightly rates to compensate for higher utility and maintenance costs. Although energy prices decreased in 2024, they were still higher than before the energy crisis. This indicates that fluctuations in energy costs may have a more significant long-term impact than an

immediate one.

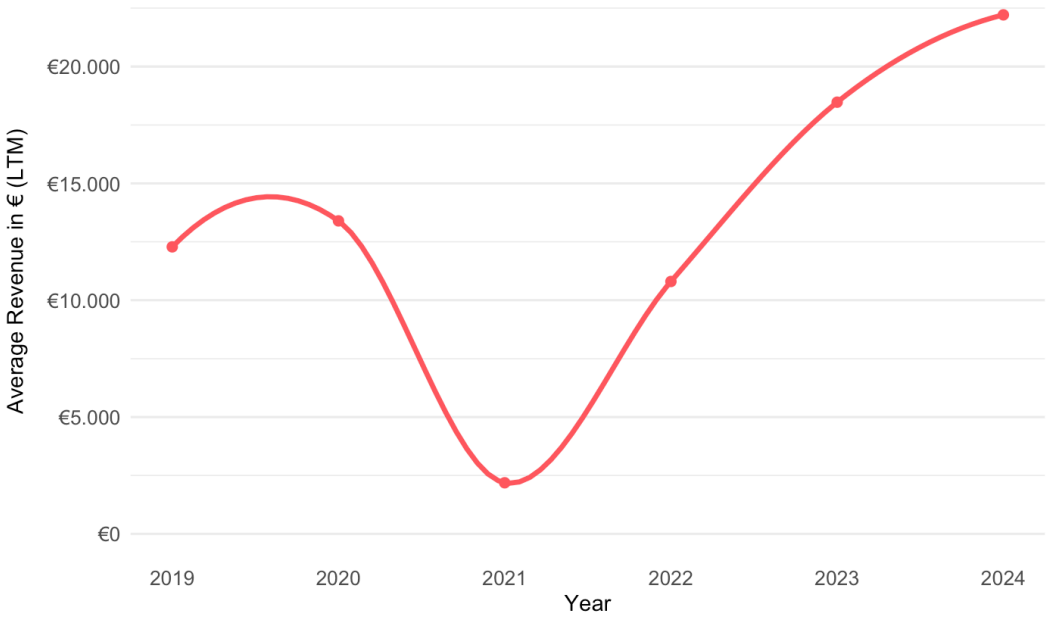


Figure 6: Average revenue of listings in Madrid over time

4.4 Empirical Strategy

To assess the effects of the European energy crisis on the Airbnb market in Madrid, this study utilizes a panel data regression methodology. This method enables the evaluation of cross-sectional variations (different listings) and time-series variations (over various periods).

The primary empirical method employed in this analysis is an entity fixed-effects (FE) panel regression. This approach effectively addresses individual heterogeneity across listings by controlling for all time-invariant factors specific to each listing, such as location, which can influence nightly rates, demand, or revenue. By focusing on variations within each listing over time, the fixed-effects model isolates the impact of time-varying variables, such as energy prices. We chose not to include time fixed effects, such as year, because our primary independent variable of interest—energy prices—varies only over time and not across different entities. Including time fixed effects would eliminate all variation in energy prices, making it impossible to identify their impact. Therefore, we focus on entity fixed effects while allowing time-varying factors, such as energy prices and market demand, to account for price variations over time.

The primary dependent variables examined in this study include price (daily listing price), market demand (assessed through reviews from the past 12 months), and estimated revenue (derived from the combination of price and demand). The key explanatory variable of interest is the energy price, represented by Spain's average electricity and gas prices for each period.

Additionally, the models include a set of time-varying control variables, such as the number of guests accommodated and the room type. As discussed in Section 2, the literature suggests that listing type and size are the primary determinants of Airbnb

prices. Therefore, we include them as control variables in our empirical model. However, due to multicollinearity among the number of guests, beds, and bedrooms—each serving as an indicator of listing size—we excluded the latter two variables from our control list.

4.4.1 Listing Prices

In this model, we examine whether listing prices change significantly due to rising energy prices. Consequently, the model is as follows:

$$Price_{it} = \beta_0 + \beta_1 \cdot EnergyPrice_t + \beta_2 \cdot Accommodates_{it} + \beta_3 \cdot RoomType_{it} + \alpha_i + \epsilon_{it}$$

In this model, the price of a listing i at time t is the dependent variable. The primary independent variable is the average energy price (in €/kWh) at time t, based on yearly average data. Additionally, the number of guests accommodated serves as a control variable. Room type is also included as a control variable and is represented as a dummy variable for the two different room types (e.g., entire home/apartment and private room). The term α_i captures time-invariant characteristics of individual listings, such as location. Lastly, ϵ_{it} represents the error term or unexplained residual.

4.4.2 Market Demand

To estimate the market demand for a listing, we used the number of nights booked in the last twelve months. In this model, price might explain market demand as well. According to Deboosere et al. (2019), Gibbs, Guttentag, Gretzel, Morton, and Goodwill (2018), Lawani et al. (2019), and Wang and Nicolau (2017), we can assume that lower-priced Airbnbs are more frequently booked. These variables are likely to be interdependent. For instance, the price of listings can affect market demand, and higher prices may lead to fewer bookings. Conversely, market demand can also impact pricing; if a listing is frequently booked, its price may increase. This reciprocal relationship creates a situation of endogeneity. Consequently, we do not include the price as a control variable. The model looks like:

$$MarketDemand_{it} = \beta_0 + \beta_1 \cdot EnergyPrice_t + \beta_2 \cdot Controls_{it} + \alpha_i + \epsilon_{it}$$

Where the market demand is the dependent variable (number of nights booked) for listing i at time t. The control variables are the number of guests accommodated and room type.

4.4.3 Revenue

The annual revenue for each listing was estimated by multiplying the nightly rate by the number of days the listing is booked throughout the year. This calculation relies on the assumption that the average nightly rate and booking frequency serve as reliable indicators for estimating a listing's revenue. However, given the simplicity of this approach and its dependence on estimated values, such as using reviews as a proxy for bookings, the revenue model is primarily included as a robustness check rather than a separate analysis. It reinforces the main findings by demonstrating whether the observed pricing responses to the energy crisis lead to significant changes in estimated listing revenue over time. The model looks like this:

$$Revenue_{it} = \beta_0 + \beta_1 \cdot EnergyPrice_t + \beta_2 \cdot Controls_{it} + \alpha_i + \epsilon_{it}$$

Where the dependent variable is the revenue of Airbnb listings over the last twelve months, and the main independent variable is the energy price. As revenue is estimated using price and market demand, we didn't control for these two variables. However, we controlled for the main drivers of price and demand: number of guests accommodated and room type.

5 Results

This section presents the results of the panel data analysis conducted to evaluate the impact of the energy price shock on listing prices, market demand, and revenue for Airbnb listings in Madrid from 2019 to 2024. Three baseline models are estimated to reflect each key relationship. Additionally, they are strengthened with additional models to assess the robustness of the findings.

5.1 Effect of Energy Prices on Listing Prices

The models used in this section evaluate the relationship between average energy prices and Airbnb listing prices, while controlling for various listing characteristics. We initiate our analysis with a baseline fixed effects model and subsequently assess the robustness of our findings by employing other models. The results obtained from the models in this section are presented in Table 4.

5.1.1 Baseline Model

The average energy price coefficient is positive and statistically significant (β = 195.292, $p < 0.01$). A one-unit increase in average energy prices is associated with a €195 increase in listing price. This finding implies that an increase in energy prices correlates with a considerable rise in listing prices, highlighting the substantial impact of energy costs on market valuations. This supports the idea that rising energy costs contributed to higher listing prices during the energy crisis, as hosts likely sought to pass increased utility costs onto guests. However, an increase of €1/kWh in energy prices is improbable, as energy prices usually range between €0.08/kWh and €0.30/kWh (see Figure 2). Therefore, a more realistic interpretation would consider the impact of a €0.10/kWh increase in energy prices, corresponding to an approximate €19.53 rise in listing price.

Conversely, the number of guests accommodated reveals a statistically significant negative coefficient (β = -3.626, $p < 0.01$), which is somewhat counterintuitive and may suggest price delution. The additional space, such as extra beds or rooms, does not lead to a proportional increase in consumers' willingness to pay. This results in diminishing marginal returns related to increased guest capacity when accounting for other characteristics.

The reference variable for the categorical variable of room type is an entire home or apartment. The results show that private rooms are priced significantly lower than entire apartments (the reference category), with an average price difference of approximately €20.33 ($p < 0.01$).

The significant association between energy and listing prices indicates a meaningful economic relationship, even if the explained variance is limited.

Table 4: Fixed Effects Models: Effect of Energy Prices on Listing Price

	Dependent variable: Airbnb Listing Price		
	(1) Baseline	(2) Log-Log	(3) Interaction
Avg. Energy Price	195.292^{***}	0.325^{***}	238.037^{***}
	(9.638)	(0.008)	(10.843)
Accommodates	-3.626^{***}	-0.020^{***}	-3.270^{***}
	(0.801)	(0.005)	(0.801)
Room Type: Private	-20.327^{***}	-0.319^{***}	2.736
	(4.828)	(0.032)	(5.524)
Energy Price $\times$ Private	—	—	-198.811^{***}
			(23.313)
Observations	18,839	18,839	18,839
R^2	0.031	0.100	0.035
Adjusted R^2	-0.173	-0.090	-0.168
F Statistic	165.540^{***}	573.777^{***}	142.908^{***}
	(df = 3; 15564)	(df = 3; 15564)	(df = 4; 15563)
Note:			*p<0.1; **p<0.05; ***p<0.01

5.1.2 Log-Log Model

In this model, the natural logarithm of the listing price and the average energy price are used to address the skewed distribution of listing prices and facilitate interpretation of the effects in percentage terms. The results from this log-log model are shown in the second column of Table 4.

The coefficient for the average energy price is positive and highly significant (β = 0.325, $p < 0.01$), indicating that a one percent increase in the average energy price is associated with an approximate 0.33% increase in listing price. Moreover, this finding supports the baseline model that listing prices increase with rising energy prices. This confirms that hosts modified their pricing strategies due to rising operational costs during the energy crisis. The log-log model supports the primary conclusion of the linear model: energy costs were at least partially passed on to consumers through increased rental prices.

In addition to the primary effect observed, the number of guests that a listing can accommodate also has a negative and statistically significant impact on its price. This reinforces the concept of price dilution, where an increase in capacity does not correspond to a proportional rise in willingness to pay. As a result, there are diminishing marginal returns associated with size. Additionally, private rooms are priced around 27.3% lower than entire homes or apartments, which supports the baseline model.

In comparison to the baseline model, the log-log specification yields a higher within R-squared value of 0.100, signifying an enhanced model fit. The log transformation likely reduces skewness and heteroscedasticity, improving the model's capacity to capture variation within listings over time.

5.1.3 Interaction between Energy Prices and Room Type

This model aims to examine whether the relationship between average energy prices and Airbnb listing prices differs among various room types. By incorporating interaction terms between energy prices and room types, this model facilitates the assessment of heterogeneous effects of energy prices on listing prices based on the type of accommodation provided. The results are provided in the third column of Table 4.

The findings from the interaction model indicate that the impact of energy prices on listing prices varies depending on the type of room being offered. For entire homes or apartments, which are the reference category, the coefficient for the average energy price is both positive and significant ($\beta = 238.04$, $p < 0.01$). This implies that as energy prices rise by €0.10/kWh, hosts of entire apartments are inclined to increase their prices by €23.8, likely to offset some of the escalating utility costs for their guests.

However, the interaction terms indicate that this relationship is weaker for private rooms. The interaction effect for these room types is negative and statistically significant ($\beta = -198.81$, $p < 0.01$). In order to gain a comprehensive understanding of this relationship, it is essential to calculate the combined effects on private room listings. This can be achieved by aggregating the main effect with the individual effect. This means that for private rooms, the estimated impact of a €1/kWh increase in average energy prices is estimated to increase the listing price by approximately €39.23. This results from combining the base effect for entire homes (€238.04) with the negative interaction effect (–€198.81). Therefore, a €0.10/kWh increase in energy prices corresponds to only a €3.92 rise in the nightly price for private rooms. This difference is both statistically significant and economically impactful.

The results suggest that private rooms exhibit less sensitivity to fluctuations in energy prices than entire homes. In other words, hosts of entire homes may significantly raise their prices in response to rising energy costs, while hosts of private rooms tend to adjust their prices much less, or not at all. One possible explanation for this relationship is that private rooms usually consume less energy because the host shares the property with the guest. Heating, lighting, and cooling a single room costs less than maintaining an entire property. This may reduce the pressure on hosts to adjust their prices in response to rising energy costs. Another possible explanation is that hosts who offer private rooms might be less focused on making a profit or may not respond as quickly to market changes (Gibbs, Guttentag, Gretzel, Yao, & Morton, 2018). They might not adjust their prices according to fluctuations in utility costs, especially if hosting is a secondary or occasional activity for them (Gibbs, Guttentag, Gretzel, Morton, & Goodwill, 2018; Gibbs, Guttentag, Gretzel, Yao, & Morton, 2018).

In summary, the findings indicate that changes in energy prices have a greater impact on entire homes or apartments compared to private rooms, possibly due to differing cost structures or pricing flexibility.

To conclude, changes in energy prices have a significant impact on Airbnb rental prices, particularly for entire home listings. The analysis reveals that as average energy prices increase, the prices of listings in Madrid also tend to rise. This suggests that hosts may be passing on higher utility costs to their guests. However, the degree of this effect varies by listing type. Private room listings show a weaker response to changes in energy prices. This is likely due to lower energy consumption, stricter pricing constraints, or different pricing strategies. These findings indicate that while fluctuations in energy prices do influence Airbnb pricing, the extent and nature of the impact depend on the type of accommodation offered.

5.2 Effect of Energy Prices on Market Demand

This section aims to determine whether energy prices influence the demand for Airbnb listings in Madrid. We will first evaluate the baseline model, followed by additional models to strengthen our findings. The results of all models are presented in Table 5.

5.2.1 Baseline Model

The results in Table 5 indicate that average energy prices significantly negatively impact booking volume. Specifically, for each one-unit increase in average energy prices, approximately 98 fewer nights are booked annually per listing (β = -97.52, p < 0.001). As mentioned, energy prices rarely rise by a euro per kilowatt-hour. To provide a more realistic interpretation, a 10-cent per kilowatt-hour (€0.10/kWh) increase in the average energy price would be associated with a decrease of roughly 9.75 booked nights per listing per year. This finding suggests that rising energy costs may reduce consumer demand, possibly because hosts are raising prices or travelers are booking less frequently as their purchasing power diminishes (Poutakidou & Menegaki, 2023).

Private rooms have significantly lower booking volumes than entire homes. They are associated with an average of 23 fewer nights booked (β = -22.63, p < 0.05) in the last twelve months, compared to entire homes.

The number of guests a listing can accommodate also negatively affects bookings, with each additional guest capacity associated with 5.04 fewer booked nights (β = -5.04, p < 0.001). This may indicate that larger properties, generally higher-priced listings, are less frequently booked.

Despite identifying several significant coefficients, the R-squared statistic is notably low (0.003), signifying that the model accounts for merely a minor fraction of the variance observed in booking volume. This finding implies that, although energy prices play a role, numerous unobserved factors likely influence demand for Airbnb accommodations.

Table 5: Fixed Effects Models: Effect of Energy Prices on Nights Booked

	Dependent variable: Nights Booked	
	(1) Baseline Model	(2) Period Interactions
Avg. Energy Price	-97.524^{***}	$-1{,}500.049^{***}$
	(17.715)	(201.438)
Period During	—	-389.199^{***}
		(19.428)
Period After	—	-111.530^{***}
		(20.471)
Accommodates	-5.039^{***}	0.140
	(1.467)	(1.113)
Room Type: Private	-22.633^{**}	-21.214^{***}
	(8.860)	(6.657)
Energy Price × During	—	$2{,}612.874^{***}$
		(202.550)
Energy Price × After	—	$1{,}404.474^{***}$
		(207.980)
Observations	19,043	19,043
R^2	0.003	0.441
Adjusted R^2	−0.205	0.325
F Statistic	13.635^{***}	$1{,}778.006^{***}$
	(df = 3; 15768)	(df = 7; 15764)
Note:		*p<0.1; **p<0.05; ***p<0.01

5.2.2 Effect of Energy Prices on Market Demand Across Periods

This model examines the relationship between average energy prices and market demand by exploring interactions with specified periods (before, during, and after) regarding the

energy crisis.

The results indicate that the main coefficient for average energy price is −1,500.05 ($p < 0.01$), which represents the effect during the reference period, i.e., before the energy crisis. The findings suggest that before the crisis, a €0.10/kWh increase in energy prices was linked to an estimated reduction of 150 nights booked per listing annually. This means that when energy prices rose prior to the crisis, demand dropped significantly, indicating that the market demand was highly vulnerable to price changes during that early period.

Conversely, during the crisis, the relationship shifted significantly positively ($\beta = 2{,}612.87$, $p < 0.01$). A 10-cent per kilowatt-hour increase in energy prices leads to an extra 111 nights booked during the crisis. However, the estimated period effects are likely confounded by the COVID-19 pandemic, particularly in the ”during” period (2021–2022). As market demand was estimated by the number of nights booked in the past twelve months, it is essential to note that the demand in 2021 was estimated using the number of reviews from the prior period (2020). In that year, travel restrictions and shifting tourism patterns significantly impacted booking behavior (Cheng et al., 2023). The significant decline in bookings reflected by the coefficient for the crisis period ($\beta = -389.20$, $p < 0.01$) underscores the impact of COVID-19 on market demand during this time. Although energy prices seem to have an influence, separating their independent effect from the shocks related to the pandemic proves to be a complex challenge. This topic will be examined in greater detail in the discussion section.

The interaction term for the period after the crisis is +1,404.47, resulting in a total effect of −95.58 when combined with the initial effect of the average energy price (-1,500). In the post-crisis period, a €0.10/kWh increase in energy prices was linked to an average reduction of 9.5 nights booked per listing annually. This shows that the extreme negative sensitivity prior to the crisis has decreased. However, energy prices have once again negatively influenced demand, but this time in a more moderate and realistic manner than before the crisis.

In summary, the energy crisis seems to affect the market demand for Airbnb listings. Generally, rising energy prices are linked to lower booking volumes, suggesting that increased operational costs may dampen demand. However, this relationship has changed over time. Before the crisis, higher energy prices led to a notable decrease in demand. Yet, during the crisis, this trend reversed, likely due to additional factors such as the COVID-19 pandemic and shifts in travel behavior. Consequently, in the post-crisis period, the previously negative relationship between energy prices and demand remains, but now the effect is more moderate. Ultimately, the findings suggest that energy prices generally negatively influence booking patterns. Still, their impact is intertwined with broader economic and contextual shocks (COVID-19), making it challenging to isolate the effect of the energy crisis alone.

5.3 Effect of Energy Prices on Revenue

This section will provide the results of the models measuring the effect of energy prices on listing revenue. Again, we will first evaluate the baseline model, followed by additional models to strengthen our findings. The results are presented in Table 6.

5.3.1 Baseline Model

The results show that the coefficient for the average energy price is €18,084.27 ($p < 0.01$), suggesting that a 10-cent per kilowatt-hour increase in the average energy price correlates with an approximate €1,808 rise in annual revenue per listing. This relationship may be attributed to the increased listing prices set by hosts in response to rising energy costs. Additionally, since only listings active throughout all periods were selected, these hosts may have specific strategies for maintaining profitability during economic uncertainty.

Table 6: Fixed Effects Models: Effect of Energy Prices on Revenue

	Dependent variable: Revenue of a Listing	
	(1) Baseline Model	(2) Interaction
Avg. Energy Price	18,084.270***	23,274.960***
	(2,611.777)	(2,944.048)
Accommodates	−918.462***	−875.204***
	(217.197)	(217.399)
Room Type: Private	−3,231.262**	−430.602
	(1,308.356)	(1,499.817)
Energy Price × Private	—	−24,142.850***
		(6,329.661)
Observations	18,839	18,839
R^2	0.005	0.006
Adjusted R^2	−0.204	−0.203
F Statistic	27.760***	24.475***
	(df = 3; 15,564)	(df = 4; 15,563)
Note:		*p<0.1; **p<0.05; ***p<0.01

The model indicates that listings capable of accommodating more guests tend to generate lower revenue. Specifically, each additional guest capacity is associated with an annual revenue decrease of €918 ($p < 0.01$). This may suggest that larger properties, which usually charge higher rates, are more vulnerable to fluctuations in demand or cancellations, particularly during high energy costs or economic uncertainty.

When comparing room types, private rooms generate significantly less revenue than entire homes, averaging €3,231 less annually ($p < 0.05$). This likely results from previous models indicating that private rooms usually have lower prices and less demand.

Despite these significant findings, the overall explanatory power of the model remains limited. The R-squared value is 0.005, indicating that the covariates included account for only a minor portion of the variation in listing revenue. This implies that numerous other factors, such as host behavior, guest preferences, competition, and local economic conditions, also play significant roles in influencing Airbnb revenues.

5.3.2 Interaction between Energy Prices and Room Type

The results in the second column of Table 6 indicate that an increase in average energy prices is linked to a statistically significant rise in revenue for entire homes and apartments, serving as the reference category (β = 23,275.96, $p < 0.001$). However, the positive impact of energy prices is significantly reduced for private room listings (β = –24,142.85, $p < 0.01$). The total effect on private rooms is -€869 (€23,274 – €24,143), indicating that revenue from private rooms is more negatively affected by rising energy

prices than entire homes. Specifically, an increase of €0.10/kWh in average energy prices decreases €86.90 in revenue for private rooms.

One possible explanation is that entire homes may be more resilient to rising energy costs because they attract travelers who are less sensitive to a listing's price. These travelers often include families or groups seeking privacy and space. Listings for entire homes typically have higher base prices, which allows hosts to transfer increased costs to guests without significantly impacting their booking volumes. In contrast, private rooms usually appeal to budget-conscious travelers, who may reduce their bookings when prices increase or when economic conditions, such as rising utility costs, diminish their purchasing power. As energy prices rise, hosts of private rooms might face challenges in increasing their rates, which could result in a decline in both bookings and overall revenue.

In summary, the results reveal that the energy crisis affects Airbnb revenue, demonstrating a positive correlation between rising energy prices and increased earnings. This trend is likely driven by hosts raising their prices to offset higher energy costs. However, the impact varies depending on the type of listing. Entire homes experience a significant revenue boost, as they may attract less price-sensitive travelers. Conversely, private rooms see a notable decline in revenue in response to rising energy prices. This is likely due to their appeal to budget-conscious guests who may be more responsive to price increases. Overall, the energy crisis has a differentiated impact on Airbnb revenue, with entire homes demonstrating greater resilience than private rooms.

6 Discussion

This study examined the effects of rising energy prices during the European energy crisis on the performance of Airbnb listings in Madrid. Using panel data from 2019 to 2024, entity fixed effects regression models were utilized to analyze how listing prices, booking activity, and estimated revenue responded to changes in energy costs. This section interprets the main findings in relation to existing literature, discusses their practical implications, acknowledges the limitations of the research, and outlines potential directions for future research.

6.1 Theoretical Implications

The findings of this study contribute to the literature on platform economies and hospitality management by highlighting the role of macroeconomic shocks, specifically the energy crisis, in shaping short-term rental market dynamics. While existing literature has primarily emphasized internal determinants such as listing attributes, location, host status, and amenities (Deboosere et al., 2019; Gyódi & Nawaro, 2021; Sainaghi, 2021; Wang & Nicolau, 2017; Zhang et al., 2017), this study provides empirical evidence that external shocks also play a substantial role.

The results highlight distinct patterns in how Airbnb listings in Madrid respond to rising energy prices. Listings of entire homes showed the ability to pass increased operational costs, such as rising energy prices, onto consumers by raising nightly prices, resulting in higher revenues. On one hand, this trend may be attributed to professional hosts specializing in these listings. Since the listings chosen for this study have been active for at least five years, these hosts likely have more experience. As a result, they can more effectively identify solutions to changing market dynamics, which consequently increases

their revenues (Kwok & Xie, 2019). On the other hand, electricity costs for this type of property may be higher. Supplying essential utilities, such as energy, to an entire home can be more expensive. As a result, hosts often find it easier to pass these rising costs on to their guests.

In contrast, hosts offering private rooms displayed less pricing flexibility and faced declining booking demand and overall revenue, suggesting they are more vulnerable to cost shocks. One possible explanation is that private rooms generally use less energy since the host shares the space with the guest. Electricity usage may be lower and cost less than for an entire property. This could reduce the pressure on hosts to adjust their prices due to rising energy expenses. Another potential reason is that hosts offering private rooms may be less driven by profit or may not respond as quickly to changes in the market (Gibbs, Guttentag, Gretzel, Yao, & Morton, 2018). Hosts may rent out their property to earn extra income, but not necessarily with the goal of maximizing revenue. They may not change their prices based on fluctuations in utility costs, particularly if hosting is a part-time or occasional activity for them (Gibbs, Guttentag, Gretzel, Morton, & Goodwill, 2018; Gibbs, Guttentag, Gretzel, Yao, & Morton, 2018).

Importantly, these pricing behaviors were also reflected in patterns of market demand. The results have shown that private rooms saw sharper declines in booking activity. There are several reasons why these listings experienced a sharper decline in demand during the energy crisis. Private rooms may attract more price-sensitive guests, such as solo travelers or students, who are likely to reduce spending or seek cheaper alternatives when prices rise. Additionally, the perceived value of private rooms may decrease due to reduced privacy and shared spaces, making them less appealing when overall costs increase. The presence of the host can also discourage bookings during uncertain times, as observed during the COVID-19 pandemic (Cheng et al., 2023). Lastly, private room hosts are often less professional and may be less likely to adjust prices dynamically, which reduces their competitiveness in volatile market conditions (Gibbs, Guttentag, Gretzel, Yao, & Morton, 2018).

These findings support existing literature that emphasizes the importance of listing type in influencing pricing outcomes. However, the effect of listing capacity observed in this study differs from previous studies. Specifically, an increase in the number of guests a listing can accommodate was associated with a decrease in price, demand, and revenue, which contradicts earlier findings that indicated a positive relationship between listing capacity and its price (Gibbs, Guttentag, Gretzel, Morton, & Goodwill, 2018; Gyódi & Nawaro, 2021; Perez-Sanchez et al., 2018; Wang & Nicolau, 2017).

Lastly, the findings of this study resonate with existing literature that explores how external shocks impact short-term rental markets. For instance, research by Benítez-Aurioles (2019) and Cheng et al. (2023) indicates that political and public health crises significantly influence Airbnb pricing strategies and booking behaviors. This study adds to that body of research by highlighting that energy price volatility, especially during the European energy crisis, is another crucial yet underexplored external factor that affects host strategies, listing performance, and market dynamics.

6.2 Practical Implications

The findings of this study carry significant implications for key stakeholders in the short-term rental market, such as hosts, policymakers, and platform operators like Airbnb.

For Airbnb hosts, these findings highlight the importance of adopting tailored pricing

and revenue strategies based on the type of listing and timing in the market. Hosts who offer entire homes, often managed by more experienced or professional hosts, can use dynamic pricing models that adjust based on cost changes (Kwok & Xie, 2019). On the other hand, hosts providing private rooms, typically operating on a smaller scale and catering to more price-sensitive guests, may find it beneficial to explore alternative value propositions. These could include improving energy efficiency or targeting specific segments of budget-conscious travelers. Adopting dynamic pricing strategies more consistently may also help these hosts improve their revenue performance (Gibbs, Guttentag, Gretzel, Yao, & Morton, 2018).

Moreover, this study showed that the impact of energy prices on demand shifted over time, negative before the crisis, positive during it, and moderately negative afterward. Therefore, hosts must understand that demand elasticity is not static and that pricing strategies must evolve accordingly. Recognizing these structural and temporal dynamics is essential for hosts who aim to remain competitive in increasingly volatile economic conditions.

The study highlights that macroeconomic shocks, such as rising energy prices, can worsen inequalities among different types of short-term rental listings. In particular, private rooms are more vulnerable due to their limited pricing flexibility, lower revenue potential, and greater sensitivity to price fluctuations. These listings often operate with narrower profit margins and may not be primarily focused on maximizing revenue.

Therefore, policymakers should avoid one-size-fits-all solutions and consider the unique economic roles that various listing types play within the rental market. Strategies such as targeted energy subsidies, efficiency grants, or tax relief designed for smaller-scale or non-commercial listings could help maintain diversity and affordability in the short-term rental sector.

Supporting the resilience of these more vulnerable listing types is a matter of equity and a way to preserve housing flexibility and stabilize tourism infrastructure during future economic or energy-related challenges.

Airbnb has an opportunity to improve its support tools for hosts by addressing the external cost pressures and market dynamics involved in its pricing systems. Currently, Airbnb's pricing recommendations are largely based on supply-demand relationships and booking probability models (Ye et al., 2018). However, these models do not take into account operational cost shocks, such as fluctuations in energy prices. While the approach discussed by (Ye et al., 2018) allows for customization at the listing level and includes booking probabilities, it fails to consider time-varying cost factors like utility expenses. This gap can significantly affect hosts' pricing strategies and how sensitive demand is across different types of listings, as shown in this study.

To better serve its hosts, Airbnb could enhance its pricing tools by incorporating cost-awareness and adaptive elasticity mechanisms. For example, a dynamic pricing system could factor in external influences such as local energy price trends and inflation rates, providing more accurate and responsive pricing recommendations. This would empower hosts to make informed pricing decisions and improve their financial resilience during economic downturns.

Furthermore, platform-mediated markets often reinforce inequalities between professionalized and informal listings (Kwok & Xie, 2019). To address this, Airbnb should invest in research focused on identifying and analyzing listing vulnerabilities to macroeconomic shocks. The insights gained could be used to offer improved guidance to hosts, personalized pricing recommendations, or even automated adjustment features during crises. By

enhancing its pricing framework in these ways, Airbnb would bolster host resilience and foster a more stable and equitable platform performance in volatile economic conditions.

6.3 Limitations

While the findings are significant, several limitations need to be addressed. First, the analysis was limited to Madrid due to data constraints. Although this focus provides valuable insights, the findings may not be generalizable to other cities, countries, or regulatory environments. Initially, we wanted to conduct a comparative analysis across multiple European cities, however, recent changes to the InsideAirbnb platform no longer allow free access to historical data for most locations. As a result, only city-level data from Madrid was available for the study period.

Second, the energy price variable was obtained from national-level statistics provided by Eurostat, which may not accurately reflect local or household-level variations in energy costs. More detailed data would likely yield more precise estimates of how fluctuations in energy prices impact hosts in different neighborhoods or building types. Additionally, more granulated listing and energy data would allow for examining seasonal patterns or short-term effects of rising energy prices.

Another limitation of this study is the reliance on proxy variables to estimate demand and revenue. The number of nights booked was approximated based on review activity and average lengths of stay. While this method is commonly used in similar research, it may introduce measurement errors. Additionally, estimated revenue is derived from estimated price and demand, which can further compound inaccuracies.

From a methodological perspective, while entity fixed effects models effectively control time-invariant characteristics, they do not account for potential time-varying confounding factors. Changes in COVID-19 regulations, local tourism policies, or inflation could all influence both prices and demand, and these factors were not addressed in the analysis.

6.4 Future Research

Several future research directions arise in light of these limitations and findings. One promising approach involves improving the modeling strategies used to estimate the effects of energy prices. For instance, additional robustness models could evaluate whether price responses vary across the distribution of listings. Higher-priced listings may absorb rising energy costs, while lower-priced ones might aggressively increase their prices to compensate.

Further, future research could explore how the impact of energy prices varies based on location-specific factors, such as neighborhood income levels, tourism intensity, or regulatory pressures. Spatial models, as employed by Chica-Olmo et al. (2020) and Gyódi and Nawaro (2021), or geographically weighted regressions (Xu et al., 2020; Zhang et al., 2017), could further highlight local patterns in cost absorption or demand resilience.

Host-level heterogeneity also warrants further investigation. By linking listings to indicators of host professionalism, such as superhost status (Wang & Nicolau, 2017), response rate (Wang & Nicolau, 2017), providing host verification (Chen & Xie, 2017), or multi-listing activity (Gibbs, Guttentag, Gretzel, Yao, & Morton, 2018). This approach would allow for modeling whether professional hosts respond more effectively to energy price shocks than occasional hosts. Combined with listing characteristics, this would provide a more comprehensive view of adaptability across the short-term rental landscape.

Lastly, using dynamic or time-lagged models may capture the delayed effects of cost shocks on host behavior, which is plausible considering the gradual pricing adjustments observed in this study.

In addition to improving modeling techniques, broadening the geographical scope of the analysis would enhance the validity of the results. By comparing cities in different climates, regulatory environments, and energy markets. For instance, by comparing northern and southern European countries, we could uncover significant structural differences in how energy shocks impact these locations. Furthermore, including local or listing-level energy consumption data would increase the accuracy of such analyses.

Future studies could also emphasize qualitative research methods, such as interviews or surveys with Airbnb hosts. This approach could provide valuable insights into how pricing decisions are made in practice and whether hosts consciously adjust their prices in response to changes in energy costs.

7 Conclusion

This study aimed to investigate the impact of the European energy crisis on Airbnb listings in Madrid, specifically examining rental prices, market demand, and estimated revenue from 2019 to 2024. By utilizing panel data from over 3,000 listings and employing entity fixed-effects regression models, the research offers empirical insights into how hosts responded to one of the most significant macroeconomic shocks in recent years.

The findings indicate that rising energy prices significantly impacted Airbnb listing prices, especially for entire homes and apartments. Hosts seemed to adjust their pricing strategies in response to increased operational costs, effectively passing part of the energy burden onto guests. However, this effect varied by accommodation type. Private rooms demonstrated a more limited response, likely due to lower energy consumption and greater sensitivity to price changes among their target users.

Regarding demand and revenue, the relationship with energy prices was more nuanced. Although rising energy prices generally lead to decreased booking activity, this trend was altered during the energy crisis due to factors like tourism recovery after the pandemic. Despite these fluctuations, hosts of entire accommodations often managed to maintain or even increase their revenue by adjusting their pricing strategies. In contrast, hosts of private rooms faced greater challenges in maintaining profitability.

In conclusion, the energy crisis significantly changed the dynamics of the Airbnb market in Madrid. Hosts adapted by implementing new pricing strategies, but the ability to maintain or increase profitability varied among different types of accommodations. These insights are crucial for hosts, policymakers, and platform operators who seek to establish more resilient short-term rental ecosystems in anticipation of future economic disruptions.

References

Barak, S. (2022, November). Global energy crisis: The impact on hospitality businesses. Retrieved November 22, 2024, from https://ensoconnect.com/blog/energy-crisis-and-hospitality/

Benítez-Aurioles, B. (2019). Barcelona's peer-to-peer tourist accommodation market in turbulent times: Terrorism and political uncertainty. *International Journal of Contemporary Hospitality Management*, *31*(12), 4419–4437. https://doi.org/10.1108/IJCHM-01-2019-0090

Bjørnland, H. C. (2022). The effect of rising energy prices amid geopolitical developments and supply disruptions.

Cai, Y., Zhou, Y., (Jenny) MA, J., & Scott, N. (2019). Price Determinants of Airbnb Listings: Evidence from Hong Kong. *Tourism Analysis*, *24*(2), 227–242. https://doi.org/10.3727/108354219X15525055915554

Camatti, N., Di Tollo, G., Filograsso, G., & Ghilardi, S. (2024). Predicting Airbnb pricing: A comparative analysis of artificial intelligence and traditional approaches. *Computational Management Science*, *21*(1), 30. https://doi.org/10.1007/s10287-024-00511-4

Casamatta, G., Giannoni, S., Brunstein, D., & Jouve, J. (2022). Host type and pricing on Airbnb: Seasonality and perceived market power. *Tourism Management*, *88*, 104433. https://doi.org/10.1016/j.tourman.2021.104433

Cebotari, L., & Paierele, A. (2024). Economic Effects of rising Energy Prices. *Proceedings of the International Conference on Business Excellence*, *18*(1), 295–302. https://doi.org/10.2478/picbe-2024-0025

Chattopadhyay, M., & Mitra, S. K. (2019). Do airbnb host listing attributes influence room pricing homogenously? *International Journal of Hospitality Management*, *81*, 54–64. https://doi.org/10.1016/j.ijhm.2019.03.008

Chen, Y., & Xie, K. (2017). Consumer valuation of Airbnb listings: A hedonic pricing approach. *International Journal of Contemporary Hospitality Management*, *29*(9), 2405–2424. https://doi.org/10.1108/IJCHM-10-2016-0606

Cheng, M., Hu, M., & Lee, A. (2023). A global perspective on the impact of COVID-19 on peer-to-peer accommodation: Human mobility, case number and lockdown policies. *International Journal of Contemporary Hospitality Management*, *35*(8), 2838–2867. https://doi.org/10.1108/IJCHM-02-2022-0221

Chica-Olmo, J., González-Morales, J. G., & Zafra-Gómez, J. L. (2020). Effects of location on Airbnb apartment pricing in Málaga. *Tourism Management*, *77*, 103981. https://doi.org/10.1016/j.tourman.2019.103981

Deboosere, R., Kerrigan, D. J., Wachsmuth, D., & El-Geneidy, A. (2019). Location, location and professionalization: A multilevel hedonic analysis of Airbnb listing prices and revenue. *Regional Studies, Regional Science*, *6*(1), 143–156. https://doi.org/10.1080/21681376.2019.1592699

Edelstein, P., & Kilian, L. (2009). How sensitive are consumer expenditures to retail energy prices? *Journal of Monetary Economics*, *56*(6), 766–779. https://doi.org/10.1016/j.jmoneco.2009.06.001

European Commision. (2024). Tourism statistics - annual results for the accommodation sector. Retrieved April 10, 2025, from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Tourism_statistics_-_annual_results_for_the_accommodation_sector

European Commission. (2022, September). Energy saving and demand reduction | Think Tank | European Parliament. Retrieved November 7, 2024, from https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)733666

Eurostat. (n.d.-a). Nights spent at tourist accommodation establishments. Retrieved June 3, 2025, from https://ec.europa.eu/eurostat/databrowser/view/tour_occ_ninat/default/table?lang=en&category=tour.tour_inda.tour_occ.tour_occ_n

Eurostat. (n.d.-b). Short-stay accommodation offered via collaborative economy platforms by months and residence of the guest - experimental statistics. Retrieved June 3, 2025, from https://ec.europa.eu/eurostat/databrowser/view/tour_ce_omr__custom_16958230/default/table?lang=en&page=time:2023

Eurostat. (n.d.-c). Short-stay accommodation offered via online collaborative economy platforms - monthly data. Retrieved June 3, 2025, from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Short-stay_accommodation_offered_via_online_collaborative_economy_platforms_-_monthly_data

Eurostat. (2023, April). Electricity & gas hit record prices in 2022. Retrieved November 9, 2024, from https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230426-2

Eurostat. (2024a). Electricity Prices Statistics | Eurostat. Retrieved January 10, 2025, from https://ec.europa.eu/eurostat/databrowser/view/nrg_pc_204__custom_14918828/default/line?lang=en

Eurostat. (2024b). Gas prices Statistics | Eurostat. Retrieved January 10, 2025, from https://ec.europa.eu/eurostat/databrowser/view/nrg_pc_202/default/line?lang=en&category=nrg.nrg_price.nrg_pc

Falk, M., Larpin, B., & Scaglione, M. (2019). The role of specific attributes in determining prices of Airbnb listings in rural and urban locations. *International Journal of Hospitality Management*, *83*, 132–140. https://doi.org/10.1016/j.ijhm.2019.04.023

Fang, B., Ye, Q., & Law, R. (2016). Effect of sharing economy on tourism industry employment. *Annals of Tourism Research*, *57*, 264–267. https://doi.org/10.1016/j.annals.2015.11.018

Fill in missing values with previous or next value — fill. (n.d.). https://tidyr.tidyverse.org/reference/fill.html

Gibbs, C., Guttentag, D., Gretzel, U., Morton, J., & Goodwill, A. (2018). Pricing in the sharing economy: A hedonic pricing model applied to Airbnb listings. *Journal of Travel & Tourism Marketing*, *35*(1), 46–56. https://doi.org/10.1080/10548408.2017.1308292

Gibbs, C., Guttentag, D., Gretzel, U., Yao, L., & Morton, J. (2018). Use of dynamic pricing strategies by Airbnb hosts. *International Journal of Contemporary Hospitality Management*, *30*(1), 2–20. https://doi.org/10.1108/IJCHM-09-2016-0540

Guttentag, D. (2015). Airbnb: Disruptive innovation and the rise of an informal tourism accommodation sector. *Current Issues in Tourism*, *18*(12), 1192–1217. https://doi.org/10.1080/13683500.2013.827159

Gyódi, K. (2019). Airbnb in European cities: Business as usual or true sharing economy? *Journal of Cleaner Production*, *221*, 536–551. https://doi.org/10.1016/j.jclepro.2019.02.221

Gyódi, K., & Nawaro, Ł. (2021). Determinants of Airbnb prices in European cities: A spatial econometrics approach. *Tourism Management*, *86*, 104319. https://doi.org/10.1016/j.tourman.2021.104319

Hill, D. (2015). How much is your spare room worth? *IEEE Spectrum*, *52*(9), 32–58. https://doi.org/10.1109/MSPEC.2015.7226609

Hu, Z. (2021). A Study of How Soaring Energy Prices Affect the Economy. *Business and Management Research*, *212*.

InsideAirbnb. (2024). Data Assumptions. Retrieved January 10, 2025, from https://insideairbnb.com/data-assumptions/

Kerneler. (2020). Airbnb Listing Data 2019. Retrieved April 19, 2025, from https://www.kaggle.com/datasets/joyshil0599/airbnb-listing-data-for-data-science

Kwok, L., & Xie, K. L. (2019). Pricing strategies on Airbnb: Are multi-unit hosts revenue pros? *International Journal of Hospitality Management*, *82*, 252–259. https://doi.org/10.1016/j.ijhm.2018.09.013

Lawani, A., Reed, M. R., Mark, T., & Zheng, Y. (2019). Reviews and price on online platforms: Evidence from sentiment analysis of Airbnb reviews in Boston. *Regional Science and Urban Economics*, *75*, 22–34. https://doi.org/10.1016/j.regsciurbeco.2018.11.003

Madrid airbnb data. (2021). Retrieved April 11, 2025, from https://www.kaggle.com/datasets/joyshil0599/airbnb-listing-data-for-data-science

Magno, F., Cassia, F., & Ugolini, M. M. (2018). Accommodation prices on Airbnb: Effects of host experience and market demand. *The TQM Journal*, *30*(5), 608–620. https://doi.org/10.1108/TQM-12-2017-0164

Moreno-Izquierdo, L., Ramón-Rodríguez, A. B., Such-Devesa, M. J., & Perles-Ribes, J. F. (2019). Tourist environment and online reputation as a generator of added value in the sharing economy: The case of Airbnb in urban and sun- and-beach holiday destinations. *Journal of Destination Marketing & Management*, *11*, 53–66. https://doi.org/10.1016/j.jdmm.2018.11.004

Parag, Y., Fawcett, T., Hampton, S., & Eyre, N. (2023). Energy saving in a hurry: A research agenda and guidelines to study European responses to the 2022–2023 energy crisis. *Energy Research & Social Science*, *97*, 102999. https://doi.org/10.1016/j.erss.2023.102999

Perez-Sanchez, V. R., Serrano-Estrada, L., Marti, P., & Mora-Garcia, R.-T. (2018). The What, Where, and Why of Airbnb Price Determinants. *Sustainability*, *10*(12), 4596. https://doi.org/10.3390/su10124596

Poutakidou, G., & Menegaki, A. N. (2023). Do Energy Prices Put the Tourism Sector at Risk? *Economies*, *11*(7), 197. https://doi.org/10.3390/economies11070197

Ribes, J. F. P., Izquierdo, L. M., Rodríguez, A. R., & Devesa, M. J. S. (2018). The Rental Prices of the Apartments under the New Tourist Environment: A Hedonic Price Model Applied to the Spanish Sun-and-Beach Destinations. *Economies*, *6*(2). https://doi.org/10.3390/economies6020023

Sainaghi, R. (2021). Determinants of price and revenue for peer-to-peer hosts. The state of the art. *International Journal of Contemporary Hospitality Management*, *33*(2), 557–586. https://doi.org/10.1108/IJCHM-08-2020-0884

Sainaghi, R., Abrate, G., & Mauri, A. (2021). Price and RevPAR determinants of Airbnb listings: Convergent and divergent evidence. *International Journal of Hospitality Management*, *92*, 102709. https://doi.org/10.1016/j.ijhm.2020.102709

Statista. (2025, March). Market cap of leading online travel companies worldwide 2025. https://www.statista.com/statistics/1039616/leading-online-travel-companies-by-market-cap/

Stefania Dinica. (2022). Madrid Airbnb Data 2022. Retrieved April 11, 2025, from https://github.com/StefaniaDinica/InsideAirbnb_SpainCities/tree/main

Tang, J., Cheng, J., & Zhang, M. (2024). Forecasting Airbnb prices through machine learning. *Managerial and Decision Economics*, *45*(1), 148–160. https://doi.org/10.1002/mde.3985

Types of places to stay - Airbnb Help Center. (n.d.). https://www.airbnb.com/help/article/5?localeusl=&_set_bev_on_new_domain=1736003876_EAYTcyZTM0NDdkNG&locale=en

Voltes-Dorta, A., & Inchausti-Sintes, F. (2021). The spatial and quality dimensions of Airbnb markets. *Tourism Economics*, *27*(4), 688–702. https://doi.org/10.1177/1354816619898075

Wang, D., & Nicolau, J. L. (2017). Price determinants of sharing economy based accommodation rental: A study of listings from 33 cities on Airbnb.com. *International Journal of Hospitality Management*, *62*, 120–131. https://doi.org/10.1016/j.ijhm.2016.12.007

Weston, R., Lawler, M., Jarratt, D., Guia, J., Prats, L., Blasco, D., Ferrer-Roca, N., & Mihalič, T. (2019). Research for TRAN Committee - European tourism: Recent developments and future challenges.

Xu, F., Hu, M., La, L., Wang, J., & Huang, C. (2020). The influence of neighbourhood environment on Airbnb: A geographically weighed regression analysis. *Tourism Geographies*, *22*(1), 192–209. https://doi.org/10.1080/14616688.2019.1586987

Ye, P., Qian, J., Chen, J., Wu, C.-h., Zhou, Y., De Mars, S., Yang, F., & Zhang, L. (2018). Customized regression model for airbnb dynamic pricing. *Proceedings of the 24th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*, 932–940. https://doi.org/10.1145/3219819.3219830

Zhang, Z., Chen, R. J. C., Han, L. D., & Yang, L. (2017). Key Factors Affecting the Price of Airbnb Listings: A Geographically Weighted Approach. *Sustainability*, *9*(9), 1635. https://doi.org/10.3390/su9091635