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The virus that devastated tourism: The impact of covid-19 on the housing market

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ABSTRACT

We study the causal impact of the negative shock on short-term rentals caused by covid-19 in the tourist-intensive city centre of Lisbon. Our difference-in-differences strategy uses a parish-level treatment relying on the pre-pandemic intensity of short-term rentals, using data between Q3 2018 and Q3 2020. The results suggest that landlords relocated properties into the long-term rental market, in which prices decrease 4.1%, while listed quantities increase 20% in the treated civil parishes vis-à-vis comparison ones. We also find evidence of an incremental negative impact on sale prices of 4.8% in treated areas. Our results are robust to the inclusion of Porto.

1. Introduction

In an attempt to control the spread of the SARS-CoV-2 virus, governments around the world have imposed lockdowns and travel restrictions, starting in January 2020, which have ravaged the global tourism and hospitality markets. This almost sudden stop is particularly striking in economies that rely a lot on tourism. According to the OECD, in 2018, Portugal ranked first in the contribution of tourism to the country’s economy, with 12.5% of its GDP directly or indirectly linked to this sector. The hotel and short-term rental sector in Portugal hosted 10.5 million guests in 2020, down from 26 million in 2019. The number of overnight stays went down to its 1993 level, mostly driven by a 75% contraction in the stays of foreign tourists, according to Statistics Portugal.

Following the outbreak of the pandemic, rents in Lisbon have contracted 11.1% in the third quarter of 2020, when compared to the same period of 2019. In this paper, we use data from the parishes of the municipality of Lisbon and Porto to study the causal impact of the severe contraction in the demand for short term rentals, stemming from the collapse of tourism, in the housing market. We use the pre-pandemic intensity of short-term rentals in different civil parishes as a measure of the intensity of the shock. Importantly, these are geographically close within the city boundaries. Treated and comparison civil parishes are located in the municipalities of Lisbon and Porto, which are home to only 18% (resp., 13%) of the population, and correspond to 3.32% (resp., 2.03%) of the surface of the respective Metropolitan Areas.

Indeed, we show that the urban neighborhoods in the treatment and control groups are similar in a number of dimensions, using granular data from a diverse set of sources, including census data, electoral data, electronic transactions, the Zomato restaurant app, and the municipality of Lisbon. We are thus able to compare residents’ demographics and socio-economic characteristics, population density and average commuting time, amenities such as retail, the restaurant market, the architectural quality of the buildings, and interventions by the municipality in urban amenities. In addition, we compare dwelling quality, size, and age brackets, across treatment and control neighbourhoods.

We thank Gabriel Ahlfeldt (editor), two anonymous referees, Simon C. Büchler, Paulo Côrte-Real, Alex Couls, and participants at the 77th Congress of the IIPF for their suggestions. Carolina Nunes generously provided us with her Covid-19 timeline, reproduced in the paper. João P. Santos gratefully acknowledges financial support by FCT PD/BD/128121/2016. This work used infrastructure and resources funded by Fundação para a Ciência e a Tecnologia (UID/ECC/00124/2013, UID/ECO/00124/2019 and Social Sciences DataLab, Project 22209), POR Lisboa (LISBOA-01-0145-FEDER-007722 and Social Sciences DataLab, Project 22209) and POR Norte (Social Sciences DataLab, Project 22209) and the research project PTDC/EGE-ECC/31213/2017. Additional financial support by Fundação Francisco Manuel dos Santos is gratefully acknowledged. All errors are our own.

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1 For the negative effects of the pandemic on travelling see, e.g., Lee and Chen (2020) and Coibion et al. (2020).
2 According to Turner et al. (2014), the short-term rental market can decrease the real estate market through negative externalities such as increased congestion, and increase it through a demand side efficient use and housing supply effects.
3 Lisbon (Porto) is just one municipality out of 18 (17) in the respective metropolitan area. The population of the municipalities of Lisbon (resp., Porto) in 2019 was 508,368 (resp., 215,945) inhabitants.

https://doi.org/10.1016/j.regsciurbeco.2022.103774
Received 16 May 2021; Received in revised form 2 February 2022; Accepted 8 February 2022
Available online 3 March 2022
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We address three research questions. Firstly, we estimate the impact of the pandemic on the housing market that is driven by the channel of the collapse in tourism and the subsequent shock in the demand for short-term rentals. This is an important research question, particularly for capital or other main cities with a high density of short-term rental properties. Secondly, we identify the impact of a sudden and sharp negative demand shock on the short-term rental market. This is in contrast with the existing literature that looks at the introduction and growth of the short-term rental platforms, or at quasi-experimental evidence from supply-constraining zoning policies. Thirdly, we are interested in the heterogeneity of the effects across different types of dwellings, in order to shed light on the market segments that are most impacted by the existence of platform-based short-term rentals.

We combine administrative data on short-term rental registries, together with quarterly data for Lisbon and Porto’s housing markets, namely, rental and sale prices, as well as on the number of dwellings for rental and for sale, to analyse the short-term impact of the pandemic. We then implement a difference-in-differences specification with a binary treatment specification that uses the civil parishes targeted by the partial bans implemented by the municipality of Lisbon in 2018 and 2019 as the treated units. We also exploit a similar ban in Porto, introduced in 2019. We complement this analysis with a continuous treatment intensity, based on the pre-pandemic share of short-term rentals in each civil parish. Our results are robust to the inclusion of Porto, the exclusion of the Northern border of Lisbon, and the exclusion of the first quarter of 2020 (when the outbreak began) from the sample. We also estimate an instrumental variable (IV) specification that uses the intensity of museums to instrument the short-term rental intensity in each parish.

We provide the following estimates for the very short-run impact of the pandemic. Firstly, we estimate a decrease in rental prices in Lisbon’s most touristic civic parishes of 3.5% and an increase of around 20% in the number of apartments for rental, vis-à-vis comparison parishes. The preferred estimate for the impact of high density of short-term rentals on the rental price represents more around one third of the overall impact on rents observed in the period. These magnitudes are significant and robust across all estimations and suggest a strong supply side effect of landlords reallocating their properties to the long-term rental market, which they can do at no cost, given that the short-term rental license does not expire. Secondly, we find a statistically significant decrease in sale prices of between 4.8% and 6.1% in treated civil parishes, but no statistically significant effect on listed quantities, when compared to the remaining civil parishes. This is suggestive of a demand shift and a change in the incumbent owners’ reservation prices. Thirdly, we show that the effects are particularly concentrated in one- and two-bedroom apartments in the rental market, suggesting a strong preference for this type of dwellings in the short-term rental market.

Arguably, there is another possible channel that can explain the decrease in housing prices in more central areas. These may be less attractive in covid-19 times, because working from home implies lower commuting costs, allowing residents to move to larger housing units outside the city. In addition, covid-19 makes it very hard to enjoy city center amenities such as bars, restaurants, and cultural events. Given the geographical and socioeconomic proximity of the treated and comparison civil parishes, and the similar availability of amenities and population density, these effects are unlikely to affect these areas differently. Moreover, the bulk of the effects is concentrated in one and two-bedroom flats, the ones that are more likely to be licensed as short-term rentals. Therefore, our specification is particularly suited to disentangle the effect of the shock on the short-term rental market from the trend of urban exodus on the housing market.

This is one of the first papers about the effect of the pandemic on real estate, and the only one to focus on the consequences of the collapse in the short-term rental market. Liu and Su (2021) finds that covid-19 reduced demand for housing in neighborhoods with high population density in the US, with previous high home prices experiencing a larger decline. Gupta et al. (2021) show that the pandemic flattened the bid-rent curve in the U.S. as house price and rent declines in city centers were counteracted by price and rent increases away from the center. Liu and Tang (2021) show that real estate prices decrease in communities with covid-19 infections. Conversely to the US case, we do not focus on the divide between the central city and the suburbs, but analyze instead the differential impacts within the city. We also contribute to the growing literature on the effects of short-term rentals on the housing market. A causal impact of the short-term rental market on housing prices is obtained by Sheppard and Udell (2016), with matched difference-in-differences in New York city, Barron et al. (2018) with an instrumental variable based on google trends, and García-López et al. (2019), using an interaction between space-invariant proximity to Barcelona’s touristic amenities and time-variant google searches of Airbnb Barcelona as an instrument. Almagro and Domínguez-llano (2019) use a structural model to show that short-term rental platforms had a significant impact on rents, amenities, and within-city migration in Amsterdam. Effects on the short-term rental supply have been documented by Koster et al. (2021), using quasi-experimental evidence from the Los Angeles’ Home Sharing Ordinances market, combining a spatial regression discontinuity design with difference-in-differences and Duuo et al. (2020) who exploit new restrictions on the registration of short-term rentals in Berlin. Finally, Gonçalves et al. (2020) exploit partial bans on new short-term rental registries in Lisbon through a difference-in-differences specification, and estimate the consequences on registries, Airbnb prices and quantities, number of transactions and housing prices, at the neighborhood level.

Our main contributions are as follows. Firstly, we analyse the impact of the pandemic on the urban landscape within the city boundaries, providing credible evidence that the reversal of the short-term rental market improves the affordability of the historical city centers in high-density cities. Secondly, given the small geographical scale of our analysis, most of the confounders that could potentially contaminate the analysis affect similarly the treatment and comparison areas. This is in contrast with the studies of city centers vs suburbs. Finally, we complement the existing literature in that, for the first time, we focus on the impact on the residential market of a demand-driven sudden stop of the short-term rental market, while the existing literature focuses on the impact of demand growth or on partial supply-side restrictions.

This paper is organized as follows. Section 2 presents a brief institutional background, whilst Section 3 describes the empirical strategy and presents descriptive statistics. Section 4 reports our results, the robustness exercises, and the heterogeneity analyses. Finally, Section 5 provides a summary of the main conclusions and policy implications of the paper.

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4 The focus of this paper is on residential real estate. Wang and Zhou (2020) and Rosenthal et al. (2021) study the impact of the pandemic on asset-level commercial real estate.

5 Bloom and Ramani (2021) coined the term donut effect to refer to this reallocation of demand away from city centers toward city suburbs in the US. Homeworking creates migration away from city centers, with fading local commerce and restaurants, eventually leading to a sale price decrease. See, e.g., Althoff et al. (2022), Delventhal and Parkhomenko (2020) and Delventhal et al. (2021). The role of mobility restrictions in limiting covid-19 spread in New York, as well as the determinants of the differential exposure to the disease, are studied by Glaeser et al. (2020) and Almagro and Orane-Hutchinson (2020), respectively.

6 Franco and Santos (2021) analyse the impact of short-term rental density on the earlier period of 2011–2016 and document significant price increases in the historical areas of Lisbon and Porto. The distributional impact of these platforms on the housing market is studied by Calder-Wang (2019) who finds that the gains from the host channel do not compensate the losses from renters in New York City, especially for those who prefer housing and location amenities that are most desirable to tourists.
2. Institutional background

We provide a short account of the evolution and legal framework of the short-term rental market in Portugal, followed by a discussion of the early effects of the pandemic.

2.1. The short-term rental market in Portugal

The decree-law 128/2014 created a straightforward online registration process for short-term rental properties. The license is available immediately and is a necessary step for the landlord to post her property on Airbnb and other home sharing platforms. Non-compliance entails a fine; moreover, platforms cooperate with the government by actively checking the licence number. Safety regulations are verified through random checks by the competent authority, Turismo de Portugal. Importantly, the license belongs to the individual, i.e., it expires when the property is sold. Moreover, the license is free to acquire and hold. Therefore, one can own a property that is registered as short-term rental, while not actually renting it in any sharing platform, and retaining the license for its positive option value. Moving back and forth between the residential rental market and the short-term one is costless.

Following this new regulation, the country witnessed an almost three-fold increase in the number of overnight stays in short-term rental properties, from 3.6 to 10.2 million between 2013 and 2019. Overnight stays by foreign tourists in all the hospitality sector almost doubled in the same period (from 8.6 to 16.4 million). To counteract rapid increases in real estate prices, the municipality of Lisbon introduced a ban on new short-term rental registries in some neighborhoods, in 2018, which it extended in 2019. The municipality of Porto followed suit in 2019.

The regions of Lisbon and Porto are responsible for 40% of the stock of 92 thousand short-term rental registries reached in 2019. Most of them are located in Lisbon, designated by the World Travel Awards as the world's leading city break in four consecutive years between 2017 and 2020. In 2019, Lisbon had 19,479 apartments registered as short-term rental properties, corresponding to almost 6% of the total dwellings. The short-term rental boom coincided with a rapid increase in real estate prices, pricing out locals and pushing some of Lisbon’s residents to the outskirts of the city. Between 2017 and 2019, median rental prices grew 21.2% in Portugal, while Lisbon and Porto saw rents rising 23.9% and 31.9%, respectively. Moreover, as presented in Figure A1 in the Appendix, Lisbon’s rental prices are well above the median of mainland Portugal.

Short-term rental density is not homogeneous even within the city boundaries that we are analysing. This is shown on the city map in panel (a) of Fig. 1, which depicts the city of Lisbon partitioned into its 24 civil parishes (freguesias), the lowest political unit in Portugal. The density of short-term rentals is the highest in historic downtown areas.

In 2018, faced with the rising concerns over housing affordability, the municipality of Lisbon restricted new registries in areas with a ratio of short-term rentals to total property above 25%, named Zonas Turísticas Homogéneas, which were then updated in 2019 to include additional neighborhoods (Proposal 204/CM/2019). In 2019, Porto’s municipality approved a similar legislation encompassing two civil parishes. We exploit these legislative changes in the identification strategy below (Edital NUD/260310/2019/CMP).

2.2. The onset of the pandemic

The pandemic led to a sudden stop in international tourism, and Portugal was not an exception. The first case of coronavirus in Portugal was reported on the 2nd of March and, one week later, the WHO declared covid-19 as a pandemic. On March 13, restrictions were imposed on the border with Spain and schools were closed. Google Mobility data presented in Figure A2 in the Appendix shows that the confinement started shortly after and was severe. By the 18th of March, Portuguese authorities had declared the entire territory to be in a State of Emergency. All non-essential services were closed, except for supermarkets, pharmacies, and gas stations. Restaurants could only serve take-away. Further restrictions on circulation and mandatory homeworking for compatible jobs were also decreed. A less severe but still constrained State of Calamity was declared on May 3rd.

As the number of new infections grew exponentially, and with countries adopting travel bans that restricted the inflow of foreigners, Portugal saw the number of foreign visitors decrease by 75%. The number of overnight stays in short-term rental accommodations also decreased considerably as can be seen in the panel (b) of Fig. 1, where we contrast the number for 2019 (in red, dashed) and 2020 (in blue). In a survey conducted by ISCTE, a Lisbon-based university, between July and October, 40% of the 868 owners of short-term rentals report that revenues from renting these units represent over half of their income streams, and 17% were considering moving to the long-term rental market. Additionally, urban areas were the most affected by the covid-19 disruption of leisure activities, with Lisbon seeing revenue breaks of 93%, and Porto of 87%. This disruption is also confirmed by Carvalho et al. (2021).

The Portuguese government has also implemented measures of financial relief to mitigate the economic fallout. Among these measures was the creation of a temporary moratorium on the repayments of capital and interest of rents, mortgages and commercial loans (at least) until September 2021. The suspension of residential and non-residential rental payments as well as of mortgage expenditures for households facing difficulties was approved in April and extended in the second semester (Decree-laws 4-C/2020 and 78-A/2020). This policy is likely to delay any impact of the crisis on the availability of housing units for sale in the market.

3. Empirical strategy

3.1. Data sources

We combine data on short-term rental registries, rental prices and quantities, and sale prices and quantities. Price variables pertain to actual transaction prices of the dwellings that were sold or rented, whereas quantity variables are listed quantities, i.e., the stock of housing units on offer in each quarter. For simplicity, we sometimes refer to the residential rental market as “long-term”. Our unit of analysis is the civil parish, of...
which there are 24 in Lisbon and 7 in Porto. Civil parishes are small units, with an average surface of 4.2 and 6 square kilometers, and had an average number of residents of 21 thousand and 31 thousand in 2019 in Lisbon and Porto, respectively.

The first data source comes from the SIR platform, collected by Confidencial Imobiliário following a protocol established with the Municipalities of Lisbon and Porto. Confidencial Imobiliário is a Portuguese databank specialized in the real estate market, whose data is used by private organizations and public institutions, such as the European Central Bank and Banco de Portugal, to produce official statistics on the Portuguese housing market. The platform collects rent and transaction prices and quantities from more than 700 real estate agents operating in the country. We collected quarterly data on the number of listed dwellings for rent and for sale, and the average transaction price. The data is disaggregated by type of dwelling, from one or less to three or more bedrooms. The data covers the 31 civil parishes in Lisbon and Porto, between the third quarter of 2018 and the third quarter of 2020, i.e., a total of 9 quarters.

In order to construct the variable that measures the short-term rental density per civil parish, we proceed as follows. We use the publicly available data on the National Short-Term Rental Registry (RNAL) to obtain the number of registered short-term rental properties in each civil parish in the fourth quarter of 2019, i.e., pre-treatment. In order to compute a measure of density, we need an estimate of the total number of dwellings per civil parish. The only parish level data on the number of dwellings is from census data, and the last available one is from 2011. We update it using yearly figures of construction and demolition of buildings in each civil parish, available from Statistics Portugal. Finally, we have to deal with the 2013 reorganization of civil parishes which, through a sequence of mergers and splits, transformed the city from its original map of 53 parishes into the current one with 24. We deal with the merged civil parishes by simply adding the dwellings.\footnote{For the one that was split (Sta. Maria dos Olivais), we use the number of registered voters as a proxy for civil parishes’ residents. We then apportion the number of dwellings in the original parish to the new, smaller ones, using the number of voters (Reorganização administrativa de Lisboa; Law 56/2012).}

Lastly, we collect data on pre-treatment neighborhood characteristics from a variety of sources, namely: (i) the 2011 census for population and dwelling characteristics; (ii) Marktest, a Portuguese subscription databank, for neighborhood amenities such as retailers and banks; (iii) the Zomato app for restaurant price and quality; (iv) publicly available data on the Lisbon municipality website for investment in urban amenities and architectural prizes; (v) electronic transaction data; (vi) voting data from the Ministry of Justice. We also use Google mobility reports to document the date of the beginning of confinement behaviours by individuals.

In Table 1, we report descriptive statistics of all the variables used in the event studies, baseline regressions, and instrumental variable specifications, which is why the data and panel C. Short-term rentals describes statistics for the data set from RNAL with information on short-term rental registries in Lisbon in 2019. Finally, Panel D. Museums shows statistics for Lisbon’s museums in 2017.

\subsection*{3.2. Methodology}

We seek to test if the housing market in civil parishes with a higher density of short-term rental properties is more hit by the pandemic than

\begin{table}[h]
\centering
\begin{tabular}{lrrrr}
\hline
\textbf{Number of Civil Parishes} & 24 & – & – & – & – \\
\textbf{A. Rental Market} & & & & & \\
\textbf{Average Rental Price (€/m²)} & 212 & 13.31 & (2.532) & 5.2 & 19.2 \\
\textbf{Number of Apartments for Rental} & 216 & 70 & (45.617) & 9 & 204 \\
\textbf{B. Sales Market} & & & & & \\
\textbf{Average Sale Price (€/m²)} & 213 & 3640.59 & (907.02) & 1733 & 6568 \\
\textbf{Number of Apartments for Sale} & 216 & 373 & (224.58) & 58 & 910 \\
\textbf{C. Short-Term Rentals} & & & & & \\
\textbf{Density of Short-term Rental Accommodations} & 24 & 0.071 & (0.111) & 0.001 & 0.440 \\
\textbf{D. Museums} & & & & & \\
\textbf{Density of Museums} & 24 & 0.872 & (1.312) & 0 & 5.648 \\
\hline
\end{tabular}
\caption{Descriptive statistics on sample characteristics for Lisbon.}
\end{table}

Notes: Panel A. Rental Market and Panel B. Sale Market present descriptive statistics for selected variables on the rental and housing markets, respectively, while panel C. Short-term rentals describes statistics for the data set from RNAL with information on short-term rental registries in Lisbon in 2019. Finally, Panel D. Museums shows statistics for Lisbon’s museums in 2017.
in the remaining ones. In the rental market, this may happen via a supply side effect with the landlords relocating their properties to the long-term rental market. In the real estate market, a supply side effect may occur if short-term rental landlords decide to sell their dwellings. We discuss below, in Subsection 3.3, why the treatment and control areas are unlikely to be differently affected by the potential urban exodus caused by the pandemic and the rapid transition to remote working for compatible occupations. As already discussed, it is unlikely that the crisis provoked by the pandemic will have effects on the real estate market through household defaults, given the moratorium policy. However, the foregone expected profit from renting to tourists may decrease the demand for apartments and may induce some owners to list the dwelling for selling.

We employ a difference-in-differences approach based on the exposure of each civil parish to short-term rentals to evaluate four outcome variables: (i) average rental price per square meter, (ii) average sale prices per square meter, (iii) number of listed dwellings available in the rental market and (iv) number of listed apartments for sale. Recall that price variables pertain to actual transaction prices, while quantities are listings. We use two treatment definitions. The first assigns all the civil parishes that contain neighborhoods that are covered by the two (2018 and 2019) Lisbon bans on new short-term rental licences to the treatment group. Importantly, these restrictions were imposed at a smaller geographical scale than that of the civil parish (Gonçalves et al., 2020). We assume that a civil parish is treated if it contains at least one restricted area. Overall, this includes 7 civil parishes in Lisbon – Misericórdia, Santa Maria Maior, Santo António, São Vicente, Arroios, Avenidas Novas and Estrela – and 2 in Porto – Bonfim and UF Centro Histórico do Porto. We also consider a continuous treatment alternative, where the treatment intensity is the density of short-term rentals in the last quarter of 2019.

We discussed in Section 2 that the sharp drop in the number of tourists occurred in March, as displayed in Panel (b) of Fig. 1, coinciding with the onset of the pandemic in Portugal on March 2nd. Actually, the number of overnight stays was around one third of the March 2019 figure. Moreover, according to Google Mobility data, the confinement started in the first weeks of March, before the State of Emergency imposed by the government, and was severe (see Figure A2 in the Appendix). Indeed, anticipation may have been driven by some worrying news from Spain and Italy, which were already into the pandemic as of February. Recall that the first case in Europe was reported in France, on the 23rd of January.

The treatment period therefore begins in March 2020, following Carvalho et al. (2021), who define March as the first month treated by the pandemic shock in their empirical strategy, based on monthly data. Given that we rely on quarterly data, our first treated period is the first quarter of 2020, that contains March. Moving the treatment to the next quarter would be problematic, given that the pre-treatment period would de facto include a treated month. One possible alternative is to eliminate the first quarter of 2020 from the analysis, given that it contains both untreated and treated months. We do so in the robustness section.

Two assumptions are necessary for inferring causality using difference-in-differences models: firstly, the absence of contemporary events that differently affected civil parishes with higher short-term rental density; secondly, the presence of parallel trends in the outcome variables prior the treatment period.

Regarding the former, it is safe to assume that there were no policies with differential impacts on civil parishes. Note that we rely on the large, world-wide, unexpected shock caused by the onset of the pandemic. Other contemporaneous events that potentially affect civil parishes differently would be second order in face of this large shock. Moreover, we are dealing with the very short-run effects: our analysis starts in the third quarter of 2018 and goes until the third quarter of 2020. In 2020, the municipal and the central governments have been essentially busy managing the effects of the pandemic. There were no urban or zoning policies implemented during this period that may have impacted civil parishes differently. Moreover, as already explained, the treatment and control areas in our study are all high urban density parishes within the city boundaries. Nevertheless, to mitigate further concerns, we provide several robustness analyses in subsection 4.3. Additionally, quarter and civil parishes fixed effects are included in the regressions. This also accounts for potential differences in the time-invariant socioeconomic and labour market characteristics of the residents, which may have been hit differently by the pandemic crisis.

We also provide a formal test of the parallel trends assumption. We carry out event study exercises to verify that, before the pandemic, the outcome variables followed parallel trends in the treatment and comparison areas. The treatment period starts in the first quarter of 2020, and the omitted quarter is the one immediately before (i.e., the last quarter of 2019). The event-study exercise is carried out using the following specification for civil parish p and quarter q:

\[
\ln(y_{pq}) = \alpha_p \times 1_p + \lambda_q \times 1_q + \delta_{pq} \times hdens_p \times 1_q + \sum_{2018Q5}^{2019Q3} \delta_q \times hdens_p \times 1_q + \epsilon_{pq}
\]

(1)

where \(y_{pq}\) is the outcome variable for civil parish p in quarter q, \(\alpha_p\) and \(\lambda_q\) are civil parishes and quarter fixed effects, \(1_p\) and \(1_q\) are indicator variables of civil parish and quarter, and \(\epsilon_{pq}\) is the error term. Finally, \(hdens_p\) is the treatment indicator, i.e., it is equal to 1 for the civil parishes that contain areas that were covered by the bans on new short-term rental registries. We also show the event studies for the continuous treatment, that implements Equation (1), by replacing the binary indicator \(hdens_p\) with the continuous variable \(STRdensity_p\), given by the ratio of short-term rental units to total number of dwellings in civil parish p.\(^{17}\)

Our baseline difference-in-differences specification is given by the following equation:

\[
\ln(y_{pq}) = \alpha_p \times 1_p + \lambda_q \times 1_q + \beta Post_{pq} \times hdens_p + \epsilon_{pq}
\]

(2)

where all variables are defined as in Equation (1) and Post_{pq} is equal to 1 in the treatment period, i.e., starting in the first quarter of 2020. The coefficient of interest, \(\beta\), measures the differential impact of the pandemic on high versus low density areas, where high density areas are defined by the bans on new short-term rentals registries introduced by the municipality. The comparison group of civil parishes that do not include areas covered by the bans is not expected to suffer the effects of the pandemic on the short-term rental market. We also implement an intensity of treatment specification, as follows:

\[
\ln(y_{pq}) = \alpha_p \times 1_p + \lambda_q \times 1_q + \beta Post_{pq} \times STRdensity_p + \epsilon_{pq}
\]

(3)

where all variables are defined as in Equation (2), and \(STRdensity_p\) is equal to the density of short-term rentals, given by the ratio of short-term rental units to total number of dwellings in civil parish p in the last quarter of 2019. Thus, the coefficient \(\beta\) gives us an estimate of the causal impact of the pandemic when the intensity of treatment with short-term rental intensity increases by one per 100 dwellings.

On a last note, in all regressions, logarithms are used to ensure a proper distribution of the dependent variable and standard errors are robust to account for heteroskedasticity.

Finally, we deal with concerns of endogenous intensity of treatment, given that short-term rental properties are not randomly located across the city. We address this issue with an instrumental variable approach, as a robustness check. The instrument is computed as the number of museums per squared kilometer of each civil parish p, \(museumsdens_p\). Therefore, our IV analysis estimates the following equations:

\(^{17}\) Callaway et al. (2021) show that the continuous difference-in-differences approach requires a strong parallel trends identifying assumption, likely to be more demanding than the usual parallel trend assumption considered in the binary treatment case and, moreover, “pre-tests commonly used in DID applications are not able to distinguish between these two types of parallel trends assumptions.”
\[ ST\text{density}_p = \alpha_p \times 1_p + \lambda_p \times 1_q + \psi \text{museumdens}_p + \epsilon_{pq} \]  

\[ \ln(y_{pq}) = \alpha_p \times 1_p + \lambda_p \times 1_q + \beta \text{Post}_q \times ST\text{density}_p + \epsilon_{pq} \]  

where all variables are defined as in Equation (2). Instrument validity relies on the exclusion restriction, i.e., the density of museums can only affect the housing market through the impact on short-term rentals and not through a direct impact.

There are two possible concerns with this instrument. The first is that residents can also be attracted by the presence of museums in the surroundings of their residence, pre-shock. The second is linked to the hypothesis of the urban exodus, i.e., the onset of the pandemic may have changed the preferences of residents, making the neighbourhoods with a higher density of museums less attractive, due to other characteristics linked to possible higher congestion of the city centre. As regards the first concern, we provide below two arguments to sustain the validity of our instrument.

As regards the second concern, we provide a full subsection below, 3.3, that mitigates the possibility that the urban exodus is stronger in treated areas. The evidence in Table 2, discussed thoroughly below, shows, e.g., that proxies of urban congestion such as average commuting time by the residents and population density are the same across treatment and control areas, and that dwellings are bigger in treated areas. Thus, the urban exodus caused by the tilting preferences due to the pandemic is probably similar across treated and control areas and, if anything, stronger in control areas.

We now tackle the first concern, with two arguments. On the one hand, we provide evidence based on survey data from Statistics Portugal. There are 64 museums in Lisbon in the period covered by our analysis. All of them were built well before our sample period, with just 4 inaugurated between 2013 and 2016. Data from Statistics Portugal shows that, in anything, stronger in control areas.

On the other hand, we provide a more formal exercise, reminiscent of Garcia-López et al. (2019), that consists in a Placebo event study where we compare the parishes with the highest museum density with the remaining ones to show that there were no differences in trends for sale prices before 2014, i.e., before the onset of the short-term rental market in Lisbon. It is shown in Figure A6 in the Appendix. Due to data availability, we use yearly data from 2009 to 2014 to compare the seven civil parishes with high density museums vis-à-vis the remaining areas in Lisbon. We do not find any difference in real estate prices for the two groups, both before and after 2012. This constitutes strong evidence that museum density does not predict different trajectories in sale prices in the period before short-term rentals.

As regards the second concern, we provide a full subsection below, 3.3, that mitigates the possibility that the urban exodus is stronger in treated areas. The evidence in Table 2, discussed thoroughly below, shows, e.g., that proxies of urban congestion such as average commuting time by the residents and population density are the same across treatment and control areas, and that dwellings are bigger in treated areas. Thus, the urban exodus caused by the tilting preferences due to the pandemic is probably similar across treated and control areas and, if anything, stronger in control areas.

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Table 2
Balance tests.

| Number of Civil Parishes | High Density | Low Density | Difference | Source and Date |
|--------------------------|--------------|-------------|------------|----------------|
| 7                        | 17           | –           |            | RNAL 2019      |
| 0.19                     | 0.02         | 0.176**     | (0.01)     | Census 2011    |
| Accommodations A. Demographics Socio-economic characteristics | 7119.472 6246.160 873.313 (0.610) | Census 2011 |
| Population Density (N/km²) |                          |            |            |                |
| Commuting time (in min)  | 21.945       | 22.320      | –0.375     | Census 2011    |
| % Below 15               | 0.111        | 0.126       | –0.015*    | Census 2011    |
| % Above 65               | 0.249        | 0.230       | 0.019      | Census 2011    |
| % Cannot read            | 0.031        | 0.032       | –0.001     | Census 2011    |
| % Higher Education       | 0.334        | 0.297       | 0.038      | Census 2011    |
| % Turnout Local Election | 0.550        | 0.530       | 0.020      | SGMAI 2017     |
| % Students with State support | 0.412 0.440 | –0.027      | (0.648)    | CML 2017-18    |
| Av daily value withdrawn in ATMs (€) | 336502.813 285008.375 51494.434 (0.543) | SBS Sep 2017 |
| Av number of withdrawals in ATMs (€) | 6268.162 4876.902 1409.260 (0.330) | SBS Sep 2017 |
| B.Amenities Prémio Valmor | 14 10 4 (0.432) | CML 2018 SBS Sep 2017 |
| ATM devices              | 68.286       | 45.471      | 22.815     | (0.160)        |
| Retailers                | 11           | 10          | 1 (0.846)  | Sales Index 2018 |
| Banks                    | 29           | 17          | 12 (0.294) | Sales Index 2018 |
| Av price of restaurants for 2 (%) | 28.696 26.430 2.266*** (0.001) | Zoamto 2018 |
| App votes for restaurants | 150.853 130.421 20.431* (0.081) | Zoamto 2019 |
| App opinions for restaurants | 65.419 57.127 8.292* (0.093) | Zoamto 2019 |
| Amount spent on construction works by CML (€) | 15.956 12.285 3.670 (0.385) | CML 2012-18 |
| Construction works by CML | 56.000 52.706 3.294 (0.830) | CML 2012-18 |
| C.Housing Stock % without heating | 0.194 0.154 0.040 | Census 2011 |
| % zero rooms             | 0.034        | 0.040       | –0.006     | Census 2011    |
| % one or two rooms       | 0.283        | 0.335       | –0.052**   | Census 2011    |
| % over two rooms         | 0.683        | 0.625       | 0.058**    | Census 2011    |
| % built 1946-2000        | 0.321        | 0.673       | –0.350***  | Census 2011    |
| % built 2001-2011        | 0.042        | 0.069       | –0.027*    | Census 2011    |

Notes: The control group is composed by civil parishes in low density areas. P-values are displayed between parenthesis considering standard errors clustered per civil parish. CML (Cámara Municipal de Lisboa) is the Town Hall. Census 2011 are available from Statistics Portugal. SGMAI (Secretaria-Geral do Min-istro do Administração Interna) is the government body responsible for election data. RNAL (Registro Nacional de Alojamento Local). Prémio Valmor is a Portu-}

18 Source: Inquérito à Educação e Formação de Adultos (IEFA).
19 Results are robust when using the density of monuments as an instrument and are available upon request.

6
On the other hand, we provide a more formal exercise, reminiscent of Garcia-López et al. (2019), that consists in a Placebo event study where we compare the parishes with the highest museum density with the remaining ones to show that there were no differences in trends for sale prices before 2014, i.e., before the onset of the short-term rental market in Lisbon. It is shown in Figure A6 in the Appendix. Due to data availability, we use yearly data from 2009 to 2014 to compare the seven civil parishes with high density museums vis-à-vis the remaining areas in Lisbon. We do not find any difference in real estate prices for the two groups, both before and after 2012. This constitutes strong evidence that museum density does not predict different trajectories in sale prices in the period before short-term rentals.

3.3. What about urban exodus?

Before we proceed to the results, we discuss the main possible confounder of our analysis. There is a nascent body of research documenting how urban exodus following the pandemic has decreased rental prices in city centers and increased them in the suburbs (see, e.g., Liu and Su (2021)). Indeed, the rapid transition to remote working for documenting how urban exodus following the pandemic has decreased rental prices for the two

On the other hand, we provide a more formal exercise, reminiscent of Garcia-López et al. (2019), that consists in a Placebo event study where we compare the parishes with the highest museum density with the remaining ones to show that there were no differences in trends for sale prices before 2014, i.e., before the onset of the short-term rental market in Lisbon. It is shown in Figure A6 in the Appendix. Due to data availability, we use yearly data from 2009 to 2014 to compare the seven civil parishes with high density museums vis-à-vis the remaining areas in Lisbon. We do not find any difference in real estate prices for the two groups, both before and after 2012. This constitutes strong evidence that museum density does not predict different trajectories in sale prices in the period before short-term rentals.

Regarding the demographics of the treated and comparison areas, displayed in Panel A, we focus on the following. First, population density and average commuting time to the workplace illustrate the urban nature of the areas. Second, population composition along age and education level, including the proportion of illiterate individuals (i.e., who cannot read) and the proportion of individuals with university education. Third, we compare the political behaviour of the residents, namely the turnout in the 2017 local election. Fourth, we proxy the prevalence of low-income families in the parishes by including the share of students who qualify for means-tested subsidised meals in basic education. Finally, we use ATM data as a proxy for income levels, considering the average daily value withdrawn and the average daily number of withdrawals.

As regards amenities, shown in Panel B, we use the number of buildings with the prestige architectural prize Premio Valmor as a proxy for the architectural quality of the parishes; we include information about the neighborhood economy, namely, the number of ATM devices, the average number of retailers and banks, and restaurant average price (for 2 people) and customer ratings (votes and opinions) from the Zomato application; and, finally, we compare the number and total spending in construction interventions by the municipal government.

Finally, Panel C compares the characteristics of the housing stock as of 2011, the last available census year, namely, age and size of dwellings (measured by the number of rooms) and whether or not they have heating.

Table 2 confirms that treated civil parishes have a substantially higher density of short-term rentals, 19% of the housing stock on average, which compares to only 2% in comparison civil parishes. This lends support to our binary treatment assignment.

The balance tests in Table 2 show that the treatment and control parishes are quite similar in terms of demographics. The only (marginally) statistically significant difference is the share of youngsters (below 15 years old) in the population, but it is very small in magnitude (1.5pp). The share of residents with university education is not statistically different across the two groups of civil parishes; this is important because the most educated individuals are the ones who are more likely to have jobs compatible with remote working, and therefore be attracted by the urban exodus to rural locations. Moreover, we also do not find differences in average commuting times for workers living in the treatment and comparison areas. Conversely, poverty levels, proxied by the share of students who qualify for means-tested free school meals, are also not statistically different across the two groups. Political participation is also statistically identical in the two groups. Lastly, both the daily average value withdrawn and the daily average number of withdrawals in ATMs are similar in the two areas, further confirming the conclusion that the demographics of the control and comparison parishes are the same.

Treatment and control parishes are also comparable when it comes to public amenities. Regarding the architectural quality of the buildings (proxied by the Valmor prizes), and the proximity of ATM devices and shops (retailers and banks) located in the neighbourhoods. In addition, public interventions implemented by the Lisbon Municipality (CML) between 2012 and 2018 are also statistically similar across the two sets of parishes. The variables retrieved from the Zomato data for the last quarter before the pandemic (Q4 2019) suggest that the restaurant

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20 Source: Inquérito à Educação e Formação de Adultos (IEFA).
21 Results are robust when using the density of monuments as an instrument and are available upon request.
22 dos Santos et al. (2021) discuss the importance of ATMs in the Portuguese context.
23 It is important to highlight that these figures refer to movements with electronic cards from Portuguese bank accounts.
market in the treated areas was slightly more lively. Nevertheless, the differences are only marginally significant (the number customer votes and opinions in the app) or quite small in magnitude (meal prices for 2 people). In particular, note that the price of a meal for two people in restaurants differs by just above two euros.

We now turn to the characteristics of the housing stock in 2011. Housing quality, proxied by the absence of heating in the dwellings, is not statistically different. Despite the simi-lar quality, there are statistically significant differences in the age and size of the housing stock. Houses in treated civil parishes are bigger, on average, and also older. Note, however, that the bigger houses in the treated parishes suggests that the urban exodus channel of people seeking more space, if it exists, is likely to be more concentrated in the comparison parishes. Interestingly, the share of studios (i.e., apartments with no separate bedrooms) is not statistically different.

Consistently with the fact that the areas with high-density of short-term rentals are the ones in the historical city centre, buildings are older in these civil parishes. In addition, the share of very recent constructions is small and only marginally higher in non-treated parishes, reinforcing the point that these comparison areas are not suburban, newly developed, neighborhoods. In fact, notice that 67% of the dwellings in low-density areas were built in the second half of last century, reinforcing the idea that these are not newly developed neighbourhoods. In order to address this issue, we implement a robustness specification in which we exclude from the sample the Northern civil parishes, which are the most recent (historically, the city developed outwards from the Tagus River bank), and show that our results are qualitatively the same.

Before we proceed to the results, we briefly discuss the characteristics of the dwellings in the short-term rental market in treated areas. Administrative data from the National Registry of short-term rentals shows that 12.3% of these registries are studios, 40% are one-bedroom flats, 26.7% two-bedroom ones, and 21% with more than two bedrooms. Therefore, the share of studios is four times as high, and the share of one and two-bedroom flats is more than twofold. Conversely, the share of bigger apartments is one third. This clearly shows that the dwellings that are licensed for short-term rentals are a selection of the stock of dwellings, tilted towards small units.

When it comes to the year of construction, 29% of licensed dwellings were built after 1951, which compares with the 36.3% of the overall stock built after 1946, according to Table 2. Therefore, the dwellings that are licensed for short-term rentals have the same age profile as the overall stock. Age proxies a number of technical and aesthetic characteristics of the dwellings, which are similar between licensed ones and the overall housing stock.

4. Results

The main results of our empirical approach are presented in this section for the rental and the sales markets. Additionally, we present some robustness checks and exploit possible heterogeneous effects in the subsequent subsections.

4.1. Rental market

The first set of results assesses the impact of the Covid-19 pandemic on average rental prices per square meter and (listed) quantities for rental in each civil parish.

To verify the parallel trends assumption, we conduct event studies for Lisbon’s civil parishes. Fig. 2 plots the values of the binary coefficients $\delta_t \times \text{hdens}_p$ in Equation (1) and highlights that both rental prices in panel (a) and (listed) quantities in panel (b) followed parallel trends before the treatment. Moreover, in the third quarter of 2020, rental prices plummeted in high density civil parishes, although the spike in the number of apartments for rental is shortly below 20%, but marginally not significant at the 5% level in the second quarter of 2020.

We also present event studies with the continuous treatment, according to (1), replacing $\text{hdens}_p$ with STRDensity$_p$, as discussed in Section 3.2. The regression specification mostly confirms the parallel trends of the two variables, with the exception of the second quarter of 2019 for rental prices, in panel (c), and the first quarters of the sample for the quantities in panel (d). Note that the coefficients of an event study with a continuous treatment have a less straightforward interpretation than those of the binary one, as the identifying assumption for this specification requires a stronger version of the parallel trends assumption, for which there is no direct statistical test (Callaway et al., 2021). For this reason, our preferred specification is the binary one; however, as the subsequent analysis shows, the magnitudes of the effects of the two specifications are comparable in the difference-in-differences settings, which further reassures the reliability of our results.

We present our baseline results, obtained from estimating Equation (2) and Equation (3) in Table 3. Columns 1 and 2 show the results for the average rental prices in the market while Columns 3 and 4 show the results for (listed) quantities. In column 1, the coefficient of Post$_p \times \text{hdens}_p$ indicates that rental prices in Lisbon’s civil parishes included in suspension areas fell around 3.5% vis-a-vis the remaining civil parishes. Column 2 reports the intensity of treatment coefficient. In order to compare it to the binary treatment one, we compute the average treatment effect as follows: given that average short-term rental density in treated (resp., comparison) areas is 19% (resp., 2%), as indicated in Table 2, column 2 suggests that rental prices in Lisbon decreased 3.6% ($-0.214 \times (0.19-0.02)$) after the pandemic. This result is in line with the one obtained for the binary treatment. Recalling that the average rental price decrease in Lisbon was 11.1%, the tourism collapse explains slightly less than one third of the price drop, according to our estimates.

We now turn to columns 3 and 4, i.e., the results on the quantity of dwellings for rental. The results show a consistent increase in the number of apartments available for rental in the traditional rental market, which ranges from a magnitude of 19.4% in the continuous treatment specification (1.141 x (19%-2%)) to 21.7% in the binary treatment one.

All in all, our results lend strong support for a sizeable impact of the pandemic on the rental market of the most touristic areas of Lisbon. There is a strong supply side effect, with landlords relocating their properties to the long-term rental market. The pandemic has created incentives to dislodge apartments to traditional rental markets, curbing trends of rising rental prices. This is consistent with fact that it is costly for property owners to relocate their property to the long-term rental market, since the license one obtains when registering an apartment in a peer-to-peer platform can be kept for free. Our results reinforce the existing evidence about the impact of short-term rentals on the rental market for long-term residents.

4.2. Sales market

In this section, we perform the same regressions as in Section 4.1 to evaluate the impact of the pandemic on the sales market. From the event study plots presented in Fig. 3, we confirm that civil parishes were on the same trends for both sale prices (in panels a and c) and listed quantities (in panels b and) before the pandemic, for both the binary and continuous treatment versions of the specifications. We find a significant reduction in prices for 2020 Q2 under the two alternative definitions of the treatment, and already in 2020 Q1 in the continuous treatment version. For quantities, the market remains quite stable, at least in the short-run.
We now turn to the results of the regressions Equation (2) and Equation (3) applied to house transactions. Columns 1 and 2 in Table 4 present the results for prices. We find a statistically significant decrease in transaction prices in treated parishes vis-à-vis the comparison ones of 4.8%. The intensity of treatment applied to sample average yields a higher negative impact of 6.1% (−0.356 × (19%−2%)). Turning to quantities, in columns 3 and 4 of Table 4, we find no statistically significant effects.

Despite a decrease in sale prices, the magnitude of changes in quantities for sale is low, suggesting that the sales market was less affected by the pandemic than the rental market. This is consistent with a slight decrease in demand or in the reservation price of the incumbent owners, possibly due to the lower expected short-term rental income. Low interest rates and moratoriums have brought some financial relief and allowed property owners to hold on to their dwellings, which may explain the non-existent spike in units for sale.\textsuperscript{27} Moreover, as we are estimating

\textsuperscript{27} According to Bank of Portugal, interest rates on mortgage payments were 0.87% in October, a year on year fall of 0.15%, and there were 751,725 moratoriums granted by the end of September, of which 42% were related to credit from housing contracts.
short run effects, the low magnitude of outcomes in the sale market is not surprising. These results reinforce the hypothesis that the most significant changes occurred in the rental market, due to a reallocation of dwellings back to the traditional and more long-term market. Data from RNAL reports listings in Lisbon fell from 19,477 to 19,356, however, as hosts can keep the short-term license while in the long-term rental market, these values underestimate the full extent of housing reallocation.

4.3. Robustness exercises

In this subsection, we present four exercises to examine the reliability of our baseline results. The first one consists in including the seven civil parishes in Porto, the second largest city (and short-term rental market) in Portugal. We exploit the fact that a ban on new short-term rental registries was also introduced in Porto, in 2019, to assign civil parishes to the treated group in this city. We compare the baseline results for rental quantities with this robustness check in Table A1 in the Appendix. We find that adding these areas does not significantly affect our previous conclusions. For the real estate market, when we include Porto in our analysis, as shown in Table A5 in the Appendix. Likewise, the results for the sales market, presented in Table A6, depict the same pattern as our baseline results.

Lastly, we present the results for the difference-in-differences instrumental variable specification spelled out in Equation (4) and Equation (5) for the rental and real estate market in Tables A7 and A8 in the Appendix. We find that the instrumental variable estimate for rental prices is similar to the OLS one, although of a slightly higher magnitude (4.1% applied to the sample means). The DID-IV estimate for the quantities in the rental market lies between the binary and the continuous IV. The IV estimate for transaction prices is even higher than the one for the continuous DID (7.6%), consistent with the result for rents.

4.4. Heterogeneity across prices and size

To verify the existence of heterogeneous effects, we re-estimate the difference-in-differences model for subsamples of dwellings according to two dimensions: (i) transactions price per-percentiles (25th and 75th), and (ii) their size, measured by the respective number of rooms.

For the first heterogeneity check, we run Equation (1) changing the dependent variable in our baseline samples for the civil parishes in Lisbon. Hence, instead of considering the average rental or transaction prices in the market, we use two alternative descriptive statistics: the 25 and the 75 percentiles. The results are displayed in Figure A5 in the Appendix. In all of them, we find statistical evidence that the parallel trend assumption seems to hold. We present the results for the rental market in panel (a) and (b). Our conclusions are not only virtually similar for the two percentiles, but also when compared with the baseline results in Fig. 2 panel (a). The same is not true when we analyse the sales market, with results converged in panel (c) and (d). Here, we find that cheaper houses (i.e., those on the 25th percentile) seem to be more affected during the second quarter of 2020 than more expensive options in the market.

Size regressions are estimated with a lower number of observations, because the data is censored when the number of observations in a triplet (dwellings type, civil parish, quarter) is below three. Therefore, one has to be cautious when interpreting the results, which can be seen in Table A9 and Table A10 in the Appendix. To increase sample sizes, we also include the results with Porto’s civil parishes. The binary treatment specification suggests that the price effect was stronger and significant for two-room apartments (~6.2%). This is consistent with the fact that more than one fourth of the stock of short-term rental units are two-bedroom flats, as discussed in subsection 2. It is also consistent with the findings by Gonçalves et al. (2020). With the intensity of treatment specification, the effect is similar for three-bedroom apartments. These effects are robust to the inclusion of Porto’s parishes.

Turning to quantities, we find a higher increase in the smaller, one-bedroom apartments in treated areas vis-à-vis the comparison ones, consistent with the negative, albeit non-significant, price effect. Again,

Table 3

| Difference in differences - rental market. | Average Rental Prices | Quantities for Rental |
|------------------------------------------|-----------------------|-----------------------|
|                                          | (1)                   | (2)                   | (3)                  | (4)                  |
| Post - Idms                              | -0.035** (0.020)      | -0.214** (0.090)      | 0.217*** (0.048)     | 1.141*** (0.164)     |
| Post - STRDensity                        |                       |                       |                      |                      |
| Civil Parish FE                          | YES                   | YES                   | YES                  | YES                  |
| Quarter FE                               | YES                   | YES                   | YES                  | YES                  |
| Observations                             | 212                   | 212                   | 216                  | 216                  |
| R-squared                                | 0.780                 | 0.783                 | 0.962                | 0.965                |

Notes: The treated civil parishes are Avenidas Novas, Arroios, Estrela, Misericórdia, Santa Maria Maior, Santo António, São Vicente. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01.

28 See https://travelbi.turismodeportugal.pt/pt-pt/Paginas/PowerBI/rnal-registo-nacional-de-a-lojamento-local.aspx
29 The northern civil parishes in Lisbon are Parque das Nações, Olivas, Lumiar, Carnide, and Santa Clara.
this is in line with the over-representation of these small units in the stock of short-term rental dwellings. We also find a positive impact on sales of two-bedroom apartments, which is significant in the intensity of treatment specification. Reassuringly, there is no effect on bigger apartments.

We now report the heterogeneous effects, presented in Table A11 and Table A12 in the Appendix. The pricing effects are concentrated in two- and three-bedroom apartments. Regarding quantities for sale, we find modest evidence for increased sales of the same types of dwellings, with low statistical significance and not robust across specifications.

5. Conclusion

The unexpected onset of the SARS-CoV-2 pandemic in Lisbon decreased the number of overnight stays to its 1993 level, mostly driven...
by a 75% contraction in those of foreign tourists, when compared to 2019. We use data on rents and transactions between the third quarters of 2018 and 2020 in a difference-in-differences setup. We find a consistent and sizeable impact on the rental market in the city’s most touristic areas. Rents decrease 3.5% more in treated areas vis-à-vis comparison ones. We also document an increase of around 20% in the number of houses in the long-term rental market. Regarding properties for sale, we find no statistically significant impact on the quantity of dwellings being offered in the market. Prices decrease 4.8%–6.1%, depending on the specifications.

The competing explanation of an urban exodus is unlikely to play a role in our setting. Firstly, balance tests show that treated and comparison areas are very similar in congestion, amenities and demographics. Secondly, both the density of short-term rentals and housing sizes are higher in treated areas. Therefore, a potential exodus would be stronger in comparison areas, and our results constitute a lower bound of the impact of covid-19. Thirdly, we find stronger results in the rental than in the sales market, which is consistent with a costless relocation of the dwellings from the short into the long-run market, on behalf of the landlords. Fourthly, the impacts are concentrated in smaller units which are over-represented in the licensed dwellings.

To our knowledge, this is the first study of the impact of the pandemic on the housing market via the mechanism of the sudden drop in the touristic demand for short-term rentals. This is in contrast with the remaining literature, which mostly concentrates on the demand side onset of the short-term rental market, or supply side shocks via zoning regulations that constrain the ability of owners to rent their property in the short-term market. As such, our conclusions are important because they highlight that prices respond to the negative demand shock immediately and strongly, i.e., this is largely a spot market with no inertia. Our results indicate that the collapse of the short-term rental market is responsible for around one third of the rent decrease observed in the city of Lisbon in the period following the pandemic.

In terms of policy implications, our results confirm, on the one hand, that the market for short-term rental does have an impact on housing affordability for local residents. On the other hand, this impact falls short of explaining the full increase of the real estate price in the last decade, and the bulk of the impact of short-term is on smaller housing units. On a different note, further disruptive shocks to international mobility, such as future pandemics or extreme weather events, are bound to create a welfare transfer from incumbent house owners to renters.

A. Figures

Fig. A1. Median Rental Price (€) per Square Meter
Source: National Statistics Institute

Fig. A2. Google Mobility Report Data for Portugal
Source: Google
Fig. A3. Timeline
Note: This timeline was generously provided by Carolina Nunes.
Fig. A4. Trends for Outcome Variables

(a) Rental Prices
(b) Quantities for Rental
(c) Sale Prices
(d) Quantities for Sale

N= 212. High Density: Avenidas Novas, Arroios, Estrela, Misericórdia, Santa Maria Maior, Santo António, São Vicente.

Fig. A4. Trends for Outcome Variables
Notes: In Panels (a) and (b), $N = 192$. In Panels (c) and (d), $N = 205$. The comparison group consists of the 17 low short-term rental density civil parishes. The regression includes quarter and civil parish fixed effects. The treatment period starts in 2020Q1. 95% confidence intervals. (d) $\ln(\text{Sale Prices})$:75 (c) $\ln(\text{Sale Prices})$:25 (b) $\ln(\text{Rental Prices})$:75 (a) $\ln(\text{Rental Prices})$:25

Notes: N = 144. The treatment group consists of the 7 civil parishes with the highest density of museums - Alcântara, Avenidas Novas, Estrela, Misericórdia, Santa Maria Maior, Santo António, and S. Vicente. The regression includes year and civil parishes fixed effects. The “placebo” treatment period starts in 2013. We remove from this sample the two museums built after 2014. 95% confidence intervals computed with standard errors clustered by civil parish.
### B. Tables

**Robustness checks.**

#### Table A1
Difference in differences - rental market: Adding Porto.

|                  | Lisbon | Porto | Quantity for Rental |
|------------------|--------|-------|---------------------|
|                  | (1)    | (2)   | (3)                |
| Post • hdens     | 0.035* | 0.013 | 0.217***           |
|                  | (0.020)| (0.021)| (0.048)            |
| Post • STRDensity| -0.214**| -0.169*| 1.141***           |
|                  | (0.096)| (0.089)| (0.164)            |
| Civil Parish FE  | YES    | YES   | YES                |
| Quarter FE       | YES    | YES   | YES                |
| Observations     | 212    | 212   | 266                |
| R-squared        | 0.780  | 0.783 | 0.864              |

Notes: The treated areas are Avenidas Novas, Arroios, Estrela, Misericórdia, Santa Maria Maior, Santo António, São Vicente, as well as Bonfim and UF Centro Histórico do Porto when including Porto’s civil parishes in the regressions. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01.

For more information on the DID-IV regressions see Table A7 in the Appendix.

#### Table A2
Difference-in-differences - sales market: Adding Porto.

|                  | Lisbon | Porto | Quantity for Sale |
|------------------|--------|-------|------------------|
|                  | (1)    | (2)   | (3)              |
| Post • hdens     | -0.048*| -0.082***| 0.024            |
|                  | (0.029)| (0.025)| (0.051)          |
| Post • STRDensity| -0.356**| -0.432***| -0.123           |
|                  | (0.145)| (0.131)| (0.171)          |
| Civil Parish FE  | YES    | YES   | YES              |
| Quarter FE       | YES    | YES   | YES              |
| Observations     | 213    | 213   | 276              |
| R-squared        | 0.925  | 0.928 | 0.948            |

Notes: The treated areas are Avenidas Novas, Arroios, Estrela, Misericórdia, Santa Maria Maior, Santo António, São Vicente, as well as Bonfim and UF Centro Histórico do Porto when including Porto’s civil parishes in the regressions. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01. For more information on the DID-IV regressions see Table A8 in the Appendix.

#### Table A3
Difference in differences - rental market: Excluding 2020 Q1.

|                  | Lisbon | Porto | Quantity for Rental |
|------------------|--------|-------|---------------------|
|                  | (1)    | (2)   | (3)                |
| Post • hdens     | -0.041*| -0.034| 0.243***           |
|                  | (0.024)| (0.022)| (0.061)            |
| Post • STRDensity| -0.215*| -0.203*| 1.323***           |
|                  | (0.110)| (0.107)| (0.146)            |
| Civil Parish FE  | YES    | YES   | YES                |
| Quarter FE       | YES    | YES   | YES                |
| Observations     | 188    | 188   | 236                |
| R-squared        | 0.799  | 0.801 | 0.877              |

Notes: The treated areas are Avenidas Novas, Arroios, Estrela, Misericórdia, Santa Maria Maior, Santo António, São Vicente, as well as Bonfim and UF Centro Histórico do Porto when including Porto’s civil parishes in the regressions. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01.
Table A4
Difference in differences - sales market: Excluding 2020 Q1.

|                  | Average Sale Prices | Quantities for Sale |
|------------------|----------------------|---------------------|
|                  | Lisbon               | Porto               |
|                  | (1)                  | (2)                 | (3)                  | (4)                  |
| Post - hdens     | −0.051 (0.034)       | −0.093*** (0.030)   | −0.016 (0.064)       | −0.042 (0.064)       |
| Post - STRDensity| −0.345* (0.191)      | −0.450*** (0.169)   | −0.236 (0.215)       | −0.426* (0.216)      |
| Observations     | 189                  | 245                 | 192                  | 248                  |
|                  | 0.930                | 0.949               | 0.937                | 0.922                |
| Civil Parish FE  | YES                  | YES                 | YES                  | YES                  |
| Quarter FE       | YES                  | YES                 | YES                  | YES                  |
|                  | Observations         | 189                 | 245                  | 192                  | 248                  |
|                  | R-squared            | 0.933               | 0.949                | 0.937                | 0.922                |
|                  | Civil Parish FE      | YES                 | YES                  | YES                  | YES                  |
|                  | Quarter FE           | YES                 | YES                  | YES                  | YES                  |
|                  | Observations         | 168                 | 168                  | 171                  | 171                  |
|                  | R-squared            | 0.733               | 0.739                | 0.964                | 0.967                |

Notes: Treated and control groups are defined as for the baseline difference-in-differences specifications before. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01.

Table A5
Difference in Differences - Rental Market: Excluding the northern civil parishes in Lisbon.

|                  | Average Rental Prices | Quantities for Rental |
|------------------|------------------------|------------------------|
|                  | (1)                    | (2)                    | (3)                    | (4)                    |
| Post - hdens     | −0.039* (0.022)        | −0.227** (0.089)       | 0.172*** (0.050)       | 1.007*** (0.170)       |
| Post - STRDensity| 0.227** (0.147)        | 0.305 (0.191)          | 0.075*** (0.089)       | 0.964 (0.007)          |
| Civil Parish FE  | YES                    | YES                    | YES                    | YES                    |
| Quarter FE       | YES                    | YES                    | YES                    | YES                    |
| Observations     | 168                    | 169                    | 171                    | 171                    |
| R-squared        | 0.901                  | 0.907                  | 0.922                  | 0.923                  |

Notes: The treated civil parishes are Avenidas Novas, Arroios, Estrela, Misericórdia, Santa Maria Maior, Santo António, São Vicente. The comparison group consists of the 12 low short-term rental density civil parishes excluding Parque das Nações, Olivais, Lumiar, Carnide, and Santa Clara. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01.

Table A6
Difference-in-Differences - Sales Market: Excluding the northern civil parishes in Lisbon.

|                  | Average Sale Prices | Quantities for Sale |
|------------------|----------------------|---------------------|
|                  | (1)                  | (2)                 | (3)                  | (4)                  |
| Post - hdens     | −0.052* (0.031)      | 0.383** (0.147)     | −0.024 (0.061)       | −0.305 (0.191)       |
| Post - STRDensity| −0.239** (0.101)     | 0.075*** (0.004)    | −0.075*** (0.004)    | 1.222*** (0.173)     |
| Civil Parish FE  | YES                  | YES                 | YES                  | YES                  |
| Quarter FE       | YES                  | YES                 | YES                  | YES                  |
| Observations     | 169                  | 169                 | 216                  | 216                  |
| R-squared        | 0.894                | 0.783               | 0.892                | 0.965                |
| KP 1st Stage F-Stat | 461.84         | 461.84             | 460.36               | 460.36               |

Notes: The treated civil parishes are Avenidas Novas, Arroios, Estrela, Misericórdia, Santa Maria Maior, Santo António, São Vicente. The comparison group consists of the 12 low short-term rental density civil parishes excluding Parque das Nações, Olivais, Lumiar, Carnide, and Santa Clara. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01.

Table A7
Instrumental variables estimates - rental market.

|                  | Average Rental Prices | Quantities for Rental |
|------------------|------------------------|------------------------|
|                  | First Stage            | Second Stage           | First Stage            | Second Stage           |
| museum dens      | 0.075*** (0.004)       | 0.075*** (0.004)       | 1.222*** (0.173)       |
| Post - STRDensity| −0.239** (0.101)       | −0.239** (0.101)       |                      |
| Civil Parish FE  | YES                    | YES                    | YES                  | YES                  |
| Quarter FE       | YES                    | YES                    | YES                  | YES                  |
| Observations     | 212                    | 212                    | 216                  | 216                  |
| R-squared        | 0.894                  | 0.783                  | 0.892                | 0.965                |
| KP 1st Stage F-Stat | 461.84         | 461.84             | 460.36               | 460.36               |

Notes: Treated and control groups are defined as for the difference-in-differences specifications before. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01.
Table A8
Instrumental variables estimates - sales market.

|                          | Average Sale Prices |                        | Quantities for Sale |                        |
|--------------------------|----------------------|------------------------|----------------------|------------------------|
|                          | First Stage          | Second Stage           | First Stage          | Second Stage           |
| **museum dens**          | 0.076*** (0.004)     |                        | 0.075*** (0.004)     |                        |
| **Post STRDensity**      |                      |                        | -0.444*** (0.121)   |                       |
| **Civil Parish FE**      | YES                  | YES                    | YES                  | YES                    |
| **Quarter FE**           | YES                  | YES                    | YES                  | YES                    |
| **Observations**         | 213                  | 213                    | 216                  | 216                    |
| **R-squared**            | 0.897                | 0.928                  | 0.892                | 0.935                  |

Notes: Treatment and control groups are defined as in the difference-in-differences specifications. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01.

Heterogeneity.

Table A9
Heterogeneous Effects - ln(Rental Prices).

|                | Lisbon                          |                        | Lisbon                          |                        |
|----------------|---------------------------------|------------------------|---------------------------------|------------------------|
|                | 1 Room or Less                  | 2 Rooms                | 3 Rooms                         |                         |
|                | (1) (2) (3) (4) (5) (6)         | (7) (8) (9) (10) (11) (12) |
| **Post hdens** | -0.041 (0.033)                  | -0.062** (0.030)       | -0.014 (0.053)                  | -0.026 (0.035)          |
| **Post STRDensity** | -0.216 (0.174)                  | -0.369** (0.176)       | -0.437** (0.197)                | -0.216 (0.172)          |
| **Civil Parish FE** | YES                            | YES                    | YES                             | YES                    |
| **Quarter FE**   | YES                             | YES                    | YES                             | YES                    |
| **Observations** | 142                             | 142                    | 163                             | 163                    |
| **R-squared**    | 0.592                            | 0.741                  | 0.748                           | 0.766                  |

Notes: Treated and control groups are defined as for the baseline difference-in-differences specifications before. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01.

Table A10
Heterogeneous Effects - ln(Quantities for Rental).

|                | Lisbon                          |                        | Lisbon                          |                        |
|----------------|---------------------------------|------------------------|---------------------------------|------------------------|
|                | 1 Room or Less                  | 2 Rooms                | 3 Rooms                         |                         |
|                | (1) (2) (3) (4) (5) (6)         | (7) (8) (9) (10) (11) (12) |
| **Post hdens** | 0.221** (0.013)                 | 0.043                  | 0.056                           | 0.228** (0.085)         |
| **Post STRDensity** | 1.344*** (0.365)               | 0.885*** (0.224)       | 0.028                           | 1.452*** (0.336)        |
| **Civil Parish FE** | YES                            | YES                    | YES                             | YES                    |
| **Quarter FE**   | YES                             | YES                    | YES                             | YES                    |
| **Observations** | 142                             | 142                    | 163                             | 163                    |
| **R-squared**    | 0.874                            | 0.870                  | 0.888                           | 0.891                  |

Notes: Treated and control groups are defined as for the baseline difference-in-differences specifications before. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01.
### Table A11
**Heterogeneous Effects - ln(Sale Prices).**

|                | Lisbon |            |            |            |            |            | Porto |            |            |            |            |            |
|----------------|--------|------------|------------|------------|------------|------------|--------|------------|------------|------------|------------|------------|
|                | 1 Room or Less | 2 Rooms | 3 Rooms |            | 1 Room or Less | 2 Rooms | 3 Rooms |            |            |            |            |            |
|                | (1)    | (2)        | (3)        | (4)        | (5)        | (6)        | (7)    | (8)        | (9)        | (10)       | (11)       | (12)       |
| Post ⋅ hdens   |        |            |            |            |            |            |        |            |            |            |            |            |
|                | −0.016 | (0.047)    | −0.091**   | (0.051)    | −0.111**   | (0.046)    |        | −0.007     | (0.044)    | −0.104***  | (0.040)    | −0.137***  |
| Post ⋅ STRDensity |        |            |            |            |            |            |        |            |            |            |            |            |
|                | −0.236 | (0.221)    | −0.627***  | (0.182)    | −0.853***  | (0.202)    |        | −0.167     | (0.203)    | −0.684***  | (0.170)    | −0.968***  |
| Civil Parish FE | YES    | YES        | YES        | YES        | YES        | YES        | YES    | YES        | YES        | YES        | YES        | YES        |
| Quarter FE     | YES    | YES        | YES        | YES        | YES        | YES        | YES    | YES        | YES        | YES        | YES        | YES        |
| Observations   | 125    | 125        | 173        | 173        | 132        | 132        | 156    | 156        | 213        | 213        | 168        | 168        |
| R-squared      | 0.860  | 0.863      | 0.872      | 0.883      | 0.882      | 0.892      | 0.900  | 0.901      | 0.924      | 0.929      | 0.923      | 0.928      |

Notes: Treated and control groups are defined as for the difference-in-differences specifications before. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01.

### Table A12
**Heterogeneous Effects - ln(Quantities for Sale).**

|                | Lisbon |            |            |            |            |            | Porto |            |            |            |            |            |
|----------------|--------|------------|------------|------------|------------|------------|--------|------------|------------|------------|------------|------------|
|                | 1 Room or Less | 2 Rooms | 3 Rooms |            | 1 Room or Less | 2 Rooms | 3 Rooms |            |            |            |            |            |
|                | (1)    | (2)        | (3)        | (4)        | (5)        | (6)        | (7)    | (8)        | (9)        | (10)       | (11)       | (12)       |
| Post ⋅ hdens   |        |            |            |            |            |            |        |            |            |            |            |            |
|                | −0.022 | (0.0946)   | 0.159*     | (0.081)    | 0.260*     | (0.092)    |        | −0.011     | (0.086)    | 0.101      | (0.082)    | 0.060      |
| Post ⋅ STRDensity |        |            |            |            |            |            |        |            |            |            |            |            |
|                | −0.329 | (0.266)    | 0.315      | (0.243)    | 0.433      | (0.249)    |        | −0.418     | (0.265)    | 0.023**    | (0.210)    | −0.085     |
| Civil Parish FE | YES    | YES        | YES        | YES        | YES        | YES        | YES    | YES        | YES        | YES        | YES        | YES        |
| Quarter FE     | YES    | YES        | YES        | YES        | YES        | YES        | YES    | YES        | YES        | YES        | YES        | YES        |
| Observations   | 125    | 125        | 173        | 173        | 132        | 132        | 156    | 156        | 213        | 213        | 168        | 168        |
| R-squared      | 0.948  | 0.930      | 0.888      | 0.892      | 0.830      | 0.864      | 0.955  | 0.955      | 0.872      | 0.871      | 0.828      | 0.828      |

Notes: Treated and control groups are defined as for the baseline difference-in-differences specifications before. Robust standard errors are depicted in parenthesis. Significance Levels: *p < 0.10, **p < 0.05, ***p < 0.01.
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