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THE IMPACT OF COVID-19 ON THE EUROPEAN SHORT-TERM RENTAL MARKET

by Elisa Guglielminetti*, Michele Loberto* and Alessandro Mistretta*

Abstract

The spread of Covid-19 and the related containment measures practically halted tourism flows, which in many countries generate a significant share of GDP. By exploiting Airbnb data covering the main tourist destinations in Europe, we investigate the impact of the pandemic on the market for short-term rentals up to early 2021. We find that the epidemic dramatically reduced both the supply of apartments available for rent and customers' demand, up to 9 months ahead. Accommodation more exposed to foreign tourism was the hardest hit and owners reacted by cutting prices with results that were mainly driven by government-mandated restrictions. All in all, our findings point to a relevant but uneven impact of Covid-19 on the accommodation sector.

JEL Classification: L83, L85, R20, R30, Z30.
Keywords: Covid-19, Airbnb, tourism, travel activities, lockdown.
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Contents

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1 Introduction

The spread of the Covid-19 epidemic worldwide has led many governments to adopt drastic containment measures. Social distancing, limits to mobility, and the forced closure of many productive sectors, together with difficult public health conditions, determined a dramatic drop in GDP in the first half of 2020. Tourism flows stopped almost entirely and resumed only partially in summer. As tourism is an important driver of the overall economy, understanding the impact of the pandemic on this sector, both in the short and in the medium-run, is very relevant.[1]

In this paper, we quantify the impact of the pandemic on the market of short-term rentals in Europe, exploiting a large sample of Airbnb listings in 19 major European cities located in 15 different countries. Although carried out on a specific market segment, the results are relevant for the whole tourism sector, considering that: i) Airbnb is the largest peer-to-peer platform of short-term rentals and in recent years has become a key player even compared to the traditional hotel industry (Guttentag, 2015; Zervas et al., 2017); ii) accommodation is strictly connected to other activities in the same sector, such as, in particular, restaurants and the cultural and recreational industry. In addition, owners of these accommodations may decide to move into the long-term rental market because of the pandemic. Then, there would be a significant and lasting effects on the supply of tourist accommodations even when the pandemic is over. These changes may deeply affect the hotel industry as well, in multiple ways. On the one side, the traditional hotel industry has suffered huge losses as a consequence of the outbreak of the pandemic; on the other, in many cases this industry has received fiscal support and our results suggest that hotel accommodations that will remain on the market may face lower competition from the sharing economy.

Our analysis has three main goals. First, we document the heterogeneous impact of the pandemic on supply, demand and prices of short-term rentals. Second, we assess whether the spread of the epidemic influenced only short-term decisions or, instead, led agents to review their plans also several months ahead. Third, we quantitatively investigate the role of government containment measures and epidemiological conditions in determining the observed trends.

We exploit a large panel dataset of Airbnb listings collected by InsideAirbnb.com, including information on the characteristics of the accommodation, calendar availability and posted prices. These data allow us to estimate supply (i.e., the number of available accommodations), demand (i.e., the booking and cancellation rates) and prices of short-term rentals. Moreover, as calendar data are forward-looking, we can look at agents' decisions up to several months ahead.

The descriptive statistics and the econometric analysis show that the outbreak of the epidemic had a dramatic negative impact on all dimensions of market activity. We find that the number of available accommodations started decreasing in March 2020. Despite improving health conditions and the loosening of containment measures, the downward trend persisted in the summer months. The supply roughly halved in some cities. Because of the uncertainty regarding the evolution of the epidemic and travel restrictions, many housing owners may have

[1]In Italy and Spain, tourism accounts for 13.2 and 14.6% of GDP, respectively. See MacDonald et al. (2020) and World Travel and Tourism Council (2017).

preferred to exit the short-term rental market and rent their homes in the long-term rental market. This outside option is one of the main features differentiating short-term rentals from the hotel industry.

After the pandemic outbreak, the share of canceled bookings increased markedly in all cities. Travelers canceled many reservations up to six months ahead, at a significantly higher rate than normal times. The number of estimated new bookings also fell sharply since March 2020. Unlike cancellations, booking rates decreased significantly even at longer horizons (beyond six months). Then, customers have significantly revised their travel plans since the pandemic outbreak without waiting for the crisis's possible resolution.

The pandemic has reversed the trend of sharply rising prices demanded by hosts. Indeed, prices have gradually decreased since March, and hosts reduced prices up to one year ahead. In September, the median change in prices across cities was -17% y-o-y (compared to +10% right before the pandemic).

In the second part of our analysis, we investigate the contribution of government restrictions and epidemiological conditions to these market trends. To disentangle these two factors quantitatively, we exploit the different timing of the epidemic spread across Europe and the timelines and intensity of the measures adopted to contain it. Our analysis includes the early phase of the epidemic, characterized by high degrees of contagion and the enforcement of strict lockdowns in many countries, and the partial revival of tourism flows in summer. For a subset of countries we also extend the sample period up to early 2021, investigating how short-term rental markets reacted to the start of the vaccination campaign. Since we observe market activity over different time horizons, we can estimate the heterogeneous effects of each driver at different future dates.

We find that mandatory government restrictions have been the primary determinant of the market trends for short-term rentals. In general, the impact of restrictive measures is negative and significant over several time horizons. On the other hand, local epidemiological conditions have a statistically significant impact only in the short term. Moreover, the magnitude of their effects is smaller than that of containment measures. We also show that the in 2020 the impact of containment measures was more related to the restrictions on internal movements rather than international ones. This is not surprising, given that domestic restrictions apply also to foreign tourists, which on average represent about half of the tourist presences in the countries we consider. International travelers are also affected by restrictions to internal movements in the destination country because they consider the difficulty in visiting touristic attractions once they have crossed the border.

In early 2021 restrictions on cross-border movements gained importance while health conditions lost relevance. These findings plausibly reflect the counteracting forces at play in that period: on the one side, European countries witnessed a new surge in infections, on the other the take off of the vaccination campaign limited concerns about the risks of infection and allowed households to look at the future with renewed optimism. This induced a partial normalization of the tourism flows which however remain oriented toward the domestic market.

The last part of our analysis digs deeper into the heterogeneous impact of the pandemic across listings with different characteristics. For each listing we use natural language processing (NLP) algorithms to identify the language of guest reviews. Then, we build a measure of international exposure in the pre-pandemic period at the listing level by computing the share of guest reviews by foreign people. We find that the pandemic has hit mostly the accommodations more exposed to international travelers, both in terms of supply – leading foreign-oriented listings to exit the market relatively more than domestic-oriented ones – and in terms of demand for those that have remained on the market. Accommodations with high international exposure are also the only ones for which we detect a net negative price effect. This suggests that for this type of listings the Covid-19 shock was akin to a negative demand shock, inducing hosts to reduce prices to attract customers.

Several paper analyse the effects of Covid-19 on the tourism sector (see, for example, Della Corte et al., 2021; Farzanegan et al., 2021; Gössling et al., 2020; Uğur and Akbıyık, 2020) and the European Airbnb market (see, for example, Boros et al., 2020; Gössling et al., 2020; Gyódi, 2021; Hossain, 2021). Compared to the existing literature, we quantify the contribution of epidemiological conditions and containment measures to the disruption of the short-term rentals market. As in Hu and Lee (2020), we analyze the short-term rental segment based on Airbnb listings. Hu and Lee (2020) use the evolution of daily guests' reviews, considered a proxy for stays in the facilities, until the end of March 2020. Unlike them, we focus on the impact of the epidemic on the longer-term hosts and guests' choices, like booking and cancellations several months ahead, and extend the sample period by one year.

Our paper is further related to the literature that evaluates the economic costs of a lockdown. Many papers show that a lockdown has a very strong negative impact on GDP but increases welfare as it reduces the number of deaths (see, for example, Eichenbaum et al., 2021). Kaplan et al. (2020) show that lockdowns have asymmetric effects among different population groups. Coibion et al. (2020) estimate that the lockdown had a negative impact on both consumption and longer-term expectations. Some studies argue that the effect of lockdown may have been minimal because people had already limited their mobility for fear of becoming infected (see, for example, Andersen et al., 2020, Goolsbee and Syverson, 2021, Rojas et al., 2020). Also Buono and Conteduca (2020) show that mobility in Europe has started decreasing before the introduction of government restrictions. However, many of these papers refer to the first wave of the epidemic; Franks et al. (2020) argue that different re-opening strategies, in the period covered by our analysis, significantly affected mobility and infection rates. Relative to these papers, we estimate the effects of containment measures by taking into account not only the initial implementation of lockdown policies but also their subsequent easing. Furthermore, we can analyze their impact in both the short-run and several months ahead.

The rest of the paper is organized as follows. Section 2 describes the data. Section 3 presents descriptive evidence on the evolution of the epidemic and related containment measures and on the reaction of European short-term rental markets. Section 4 quantifies the impact of Covid-19 using data at the city level. Section 5 exploits micro data to investigate the heterogeneous impact of the pandemic on different types of listings. Section 6 concludes.

2 The data

Our main sample includes Airbnb listings for 19 major European cities in 15 different countries.[2] Since these cities are the capital of their country or major destination of tourist flows, this sample allows us to identify the main trends at the European level. We retrieve web-scraped data on listings from InsideAirbnb.com, an independent project collecting data from the Airbnb website to study the implications of short-term rentals on the housing market. For each city, we have snapshots of listings collected monthly between April 2018 and September 2020, although they may not refer to the same day of the month. For a sample of Italian, French and Spanish cities, our data are up to April 2021.[3] A snapshot is the collection of all listings in a city published on www.airbnb.com on a given day. When we aggregate data at the city level we keep only listings of entire apartments, excluding shared or private rooms that may be differently affected by the ongoing epidemic due to social distancing measures.

All information in our dataset is public and displayed on the Airbnb site. We observe many details for each listing (for example, information about the host, physical characteristics of the house, location, rental policy), including the calendar availability for the following 365 days, the guests' reviews, and the price per night. We mainly use the information on calendar availability, which allows us to estimate the number of bookings and cancellations and occupancy rates.[4] We can infer the evolution of the occupancy rates also through guests' reviews, although we cannot use them to compare the occupancy rate across cities. Finally, calendar data allow observing prices and estimating hedonic indexes over different time horizons.

The analysis of these data requires some caution. Airbnb is an online marketplace that allows homeowners (hosts) to offer rental services to other people (guests). Unlike the standard hotel and accommodation industry, a major share of suppliers consists of non-professional operators.[5] Those hosts may not rent the house regularly and may not update the calendar frequently; thus, calendar data can be the same in two different snapshots, and we cannot infer activity in the time-lapse. Furthermore, some hosts deliberately limit the time horizon for which they accept bookings (for example, giving the possibility to book only up to 90 days ahead). In this case, the house appears unavailable beyond this time horizon.

To limit these issues and identify more active hosts in the market, we make the following choices. First, from each snapshot, we keep only listings with an updated calendar compared to the previous observation. We consider the calendar updated if at least one of the following conditions is satisfied: (i) there is a change in the availabilities compared to the previous snapshot; (ii) the host has changed its prices. Second, if all the calendar dates for a listing are unavailable from a specific date onwards, we assume they are not bookable; hence, we include

[2]The cities are Amsterdam, Athens, Barcelona, Berlin, Brussels, Copenhagen, Dublin, Florence, Geneva, Lisbon, London, Madrid, Milan, Oslo, Paris, Rome, Stockholm, Venice and Vienna.

[3]In Section 5 we focus our analysis on Italy, French and Spain, and we will include in the sample also minor cities to increase the sample representativeness at the country level. We do not consider these cities in the main analysis so as not to skew the sample toward these three countries.

[4]For each day in the calendar, we can only observe if a house is available for booking or not. An apartment cannot be available for booking because it was already booked or because the host does not accept reservations for that particular day.

[5]Recently, intermediaries have emerged who specialize in taking empty houses over from owners and managing short-term rentals on the Airbnb marketplace.

these listings in our analysis only for the period they are bookable.

We select the most active listings and hosts on the market using the previous criteria. In this work, we are interested in quantifying the effects of the Covid-19 epidemic on the supply and demand for short rentals promptly. Considering listings with outdated calendars, or more generally host not very active on the market, would have led to underestimating the effects of the shock.[6]

3 Stylized facts

3.1 The evolution of the epidemic and containment measures

To gauge the epidemic's impact on short-term rental markets, we mainly rely on data drawn from the European Center for Disease Prevention and Control (ECDPC) and the Institute of Health Metrics and Evaluation (IHME). ECDPC collects daily data on the number of Covid-19 cases and deaths and weekly data on tests. We complement these data with information on intensive care units (ICUs) used for Covid-19 patients taken from the IHME.[7]

To measure the spread of contagion, we focus on the number of Covid-19 infections and occupation of ICUs. Statistics may not be fully comparable across countries but for our analysis what matters is the perceived risk of contagion, which depends on reported data. Moreover, the number of reported infections depends on the testing capacity, which has gradually increased since the early phase of the pandemic. For this reason, we focus on the positivity rate, namely the number of infections out of the number of tests.

We measure the restrictiveness of government policies adopted to fight the epidemic through the Oxford Stringency Index. The index is measured on a scale from 0 to 100 – where higher values denote more restrictive policies – and is broadly comparable across countries.[8] In our econometric model, we consider the sub-components of the Stringency Index separately, in order to single out the role of restrictions to international travels.[9]

The first Covid-19 case was reported in China, in the Hubei region, on January 9, 2020.[10] Among the selected European countries considered here, Italy was the first one, on January 23, to introduce measures aimed at detecting passengers with symptoms possibly related to Covid-19 flying from China. In Europe, the first Covid-19 cases were identified at the end of January; however, the disease remained undetected until the end of February, when infection clusters in

[6] We do not believe that these are universal criteria to adopt in all circumstances, and they may not be necessary for other analyses. After all, Airbnb aims to allow people (not professionals) to share their houses with other people in return for a fee. The calendar may be outdated because bookings are very low in some periods of the year.

[7] For countries and/or periods for which ECDPC data are not available (e.g., Switzerland), we use IHME data or data taken from Our World in Data (OWD).

[8] Conteduca et al. (2020) identify some limitations of the Oxford Stringency Index. They propose to redefine the score of some variables and to weigh the restrictive sub-national measures by the share of the targeted population. Though acknowledging its limitations, we use the Oxford Stringency Index to ensure comparability with other studies.

[9] The Oxford Stringency Index is a weighted average of eight sub-components: for a detailed description, see Petherick et al. (2020). In the Appendix, we describe how we separate the domestic and the international sub-components.

[10] Several studies have then proved that the coronavirus was already diffused; however, here we are interested in the official communication and the spread of news to the public.

Northern Italy appeared. In Italy the epidemic gained momentum quickly: in the first week of March the number of new cases per day more than tripled and the positivity rate exceeded 20%. This prompted the Italian authorities to impose a nationwide lockdown on March 9. The epidemic spread in all European countries in March and April, albeit with different timings and intensities. Beside Italy, the hardest and earlier hit countries were Spain, Austria and Belgium. In these countries the positivity rate reached its peak already in late March. On the other side of the spectrum, in Germany, Portugal and Greece the positivity rate never exceeded 10% during the first wave. In the first two panels of Figure 1 the spread of the contagion is represented by the evolution of the infection and the positivity rates, where the latter controls for the testing capacity.

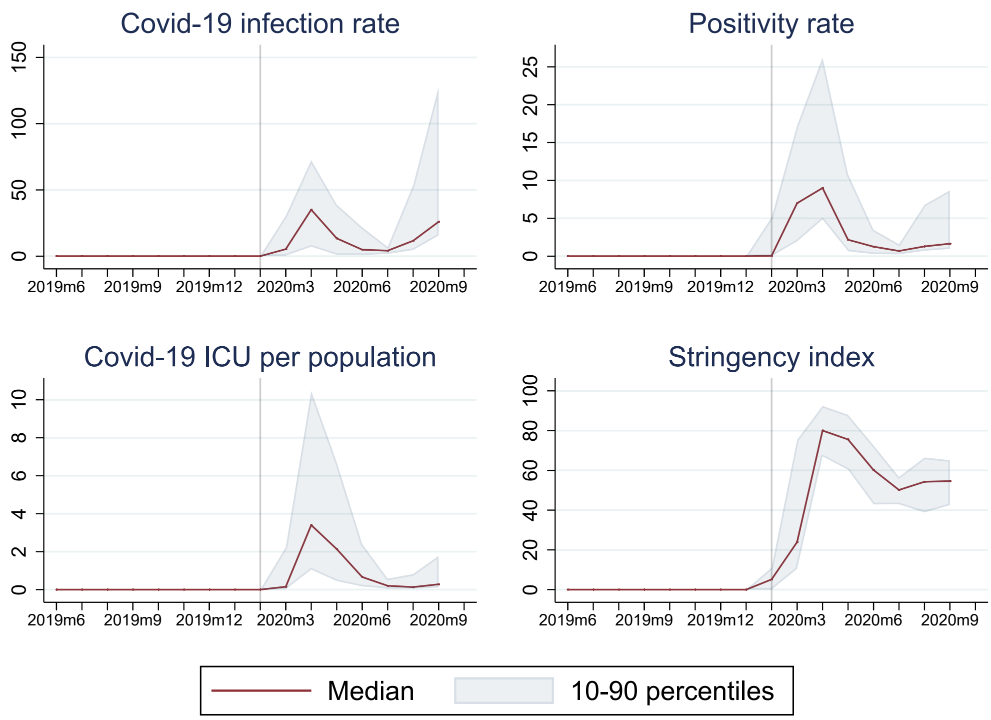
The severity of the epidemic can be further judged with respect to the strain on the health-care system. This can be measured by the share of ICUs dedicated to Covid-19 patients over the total population and it depends not only on the severity of contagion but also on the ability of local authorities to keep the sanitary situation under control and on pre-existing conditions. Furthermore, ICU occupation generally peaks later than the positivity rate and is more persistent, given the length of stay of the patients (Figure 1, third panel). These somewhat different patterns allow us to distinguish the impact of the spread of contagion from that of overwhelmed ICUs, even in a context of declining infection rates.

Another dimension of heterogeneity regards the containment measures adopted in response to the spread of the virus. Italy, Spain and Austria enforced a strict lockdown already in March (Figure 1, fourth panel). Other countries adopted different approaches: the UK government, for instance, imposed shutdown orders only when the strategy of achieving herd immunity appeared to be too costly in terms of human lives. Sweden was the only European country that relied on mild mitigation policies, notwithstanding relatively high levels of contagion and ICU occupancy.

In May, the epidemiological situation improved and containment measures were eased; since June, people were allowed to travel also outside their country of residence, although with some restrictions. However, some European countries, like Spain, experienced a new surge in Covid-19 cases already in early July. In France, the UK, the Netherlands and Belgium the contagion quickly spread in August and September, while in Italy and Germany the diffusion of the infection remained modest until the beginning of October.[11] Despite rising infection rates, until September – when our main analysis ends – governments avoided a new tightening, hoping to keep the evolution of the epidemic under control while preserving economic activities.

[11]See Borin et al., 2020 for a detailed analysis of the worldwide evolution of the pandemic since the summer of 2020.

Figure 1: The evolution of the epidemic and policy responses



Note: The infection rate is measured as Covid-19 new cases per 100,000 population. The positivity rate is the share of detected infections over total tests. The Covid-19 ICU per population is measured as new ICUs occupied by Covid-19 patients per 100,000 population. The Stringency Index can take values from 0 (no restrictions) to 100 (maximum level of restrictions).

3.2 The effects of the epidemic on short-term rental markets

Difficult health conditions and containment measures adopted by governments led to a collapse in the mobility of people between cities and between countries. Consequently, levels of activity in the accommodation sector, and thus also in the short-term rental market, dropped dramatically.

This Section describes the evolution of the short-term rental market after the outbreak of the coronavirus epidemic under different dimensions. The epidemic led to a gradual decrease in the number of houses on the market. Customers reacted to the shock by canceling existing bookings and drastically reducing new bookings across all time horizons. Therefore, the accommodation facilities' occupancy rates dropped, and owners progressively reduced the required prices, even on longer time horizons.

For each variable, we consider the possibility that the effects of the epidemic may have been heterogeneous at different time horizons (denoted by h), going from 1 month ahead up to 9 months ahead. Then, we compute the year-on-year monthly variations for each city and show how the 10th, 50th and 90th percentiles of the distribution of these variations have changed over time.

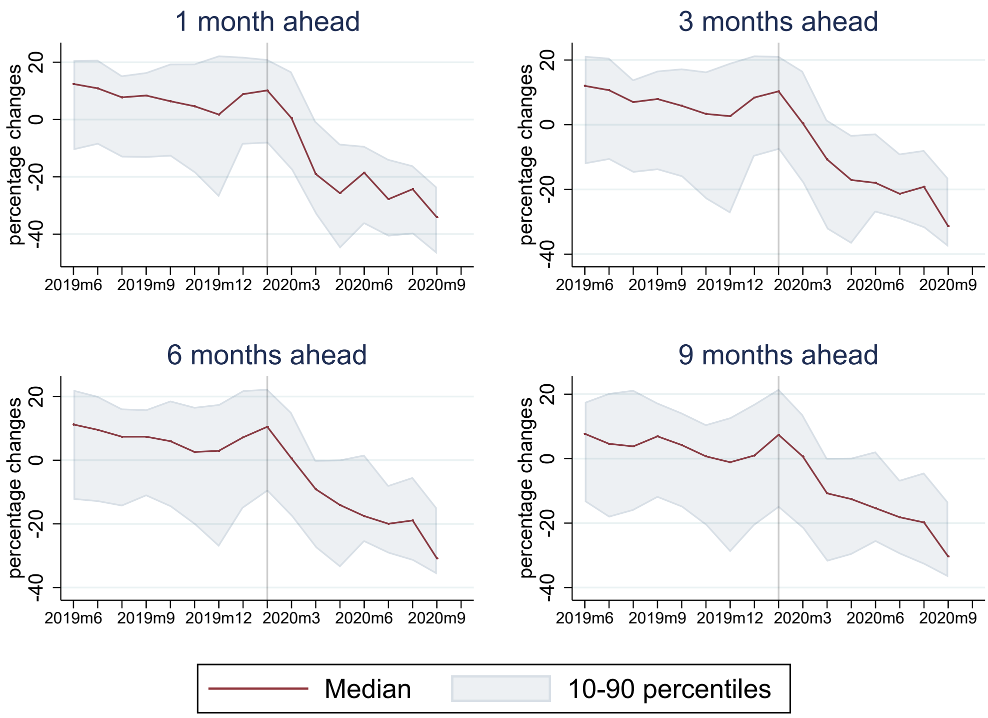
The supply of short-term rentals. Before the Covid-19 outbreak, the market for short-term rentals was expanding in most of the cities in our sample. In January and February 2020, the listings decreased significantly only in Dublin and Amsterdam due to pre-existing downward trends. The y-o-y median growth rate of available accommodations across cities was about 10%.

In Vienna, Athens and Brussels, growth rates were close to 20%.

This positive trend was interrupted in March (Figure 2). Initially, the supply contracted in Italian cities, which were the first to be affected by the epidemic. The growth rate turned negative, from 9% to -14% in Rome and from 17% to -9% in Milan. Subsequently, the worsening affected all the other cities; in May, the growth rate of the number of listings was negative everywhere.

The drop in supply was quite strong between March and May, but the decline continued even afterward in most cities. Between May and September, the offer was about a quarter lower than the corresponding period in 2019. In Dublin and Amsterdam, the offer roughly halved.

Figure 2: Number of short-term rentals



Note: Y-o-y percentage changes. Supply can change over different time horizons because some hosts allows reservations only for a limited period forward in time.

The sharp drop in supply observed in the spring can be mostly explained by governments' restrictive measures, which reduced the number of hosts actively operating in the market. Despite improving health conditions and the loosening of containment measures, the downward trend also persisted in the summer months. This pattern is probably explained by the uncertainty regarding the evolution of the epidemic and the occurrence of new travel restrictions. In fact, many owners may have preferred to rent their homes in the long-term rental segment, waiting for a return to normality.

Cancellations and new bookings. The effects of the epidemic on current and future demand are visible. First, we estimated the share of booking cancellations over different time horizons.[12]

In March 2020, the share of one-month-ahead bookings that were canceled increased markedly in all cities (Figure B.1). The median increase compared to March 2019 was about 40 percentage points. In some cities, the increase in the cancellation rate exceeded 60 points.[13] The one-month-ahead cancellation rate was much higher compared to normal times, even in the following months, although the gap gradually narrowed.

Initially, the impact on cancellations was higher in the Italian touristic cities. The one-month-ahead cancellation rate in Rome, Venice and Florence was about 70% in March. The worsening was milder in the capitals of Northern European countries. The impact was also lower in Milan (except in March). That could be due to the stronger business orientation of Milan, which plausibly makes the hosts' activity relatively less dependent on the dynamics of tourism flows compared to the other cities under scrutiny.[14] We observe a similar pattern for London, although the pandemic severely hit the UK.

The sharp increase in the share of pre-existing bookings that were canceled in March and April is plausibly due to the mobility restrictions imposed by the governments.[15] However, travelers also canceled many reservations up to 3 months ahead, at a rate significantly higher than in normal times. Cancellation rates converge to those prevailing in normal times from the six-months ahead horizon.

The number of estimated new bookings also fell sharply since March (Figure B.2). In April, the booking rate's median gap across cities compared to a year earlier reached -23 percentage points. Again, Venice recorded the worst performance: the ratio of new bookings over previously available accommodations one-month-ahead fell to 6%, about 40 points lower than in 2019. All the main tourist destination cities were also hit hard, mostly because many bookings for the summer months are usually made in spring.

Unlike cancellations, booking rates decreased significantly even at longer horizons (beyond six months). This indicates that customers have significantly revised their travel plans since the pandemic outbreak without waiting for the crisis's possible resolution. However, cancellation policies' flexibility may explain the fact that cancellations were instead limited to a shorter horizon. Indeed, in March and April, some guests may have decided to wait before cancelling their reservations for the summer months as they could do it without incurring immediate penalties.

Occupancy. Because of the joint occurrence of more cancellations and fewer new bookings, the vacancy rate – measured as the share of listings available for booking – skyrocketed in all

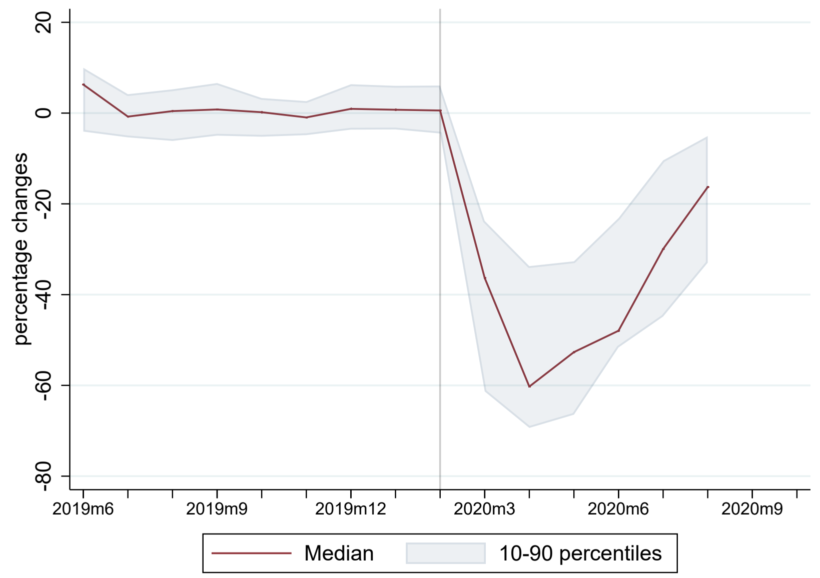
[12] We estimate the share of cancellations instead of the absolute number to smooth out the strong seasonal pattern on these statistics. Technical details about the estimation of all indicators discussed in this note are in the Appendix.

[13] In normal times, the one-month-ahead cancellation rate varies between 2% and 10%.

[14] According to Istat data, in 2018 the percentage of nights spent by foreigners in the province of Milan was almost half of the average share in the provinces of Rome, Venice and Florence.

[15] Formally, Airbnb remained active throughout the lockdown period because the short-term rentals offered through the platform could provide accommodation also for health workers. In Italy, for instance, Airbnb rentals are not formally considered a part of the accommodation sector as can be run as a private rental activity. In practice, however, most of Airbnb services target the tourism sector (Guttentag et al., 2018), which was forcefully shut down.

Figure 3: Reviews



Note: Y-o-y percentage changes.

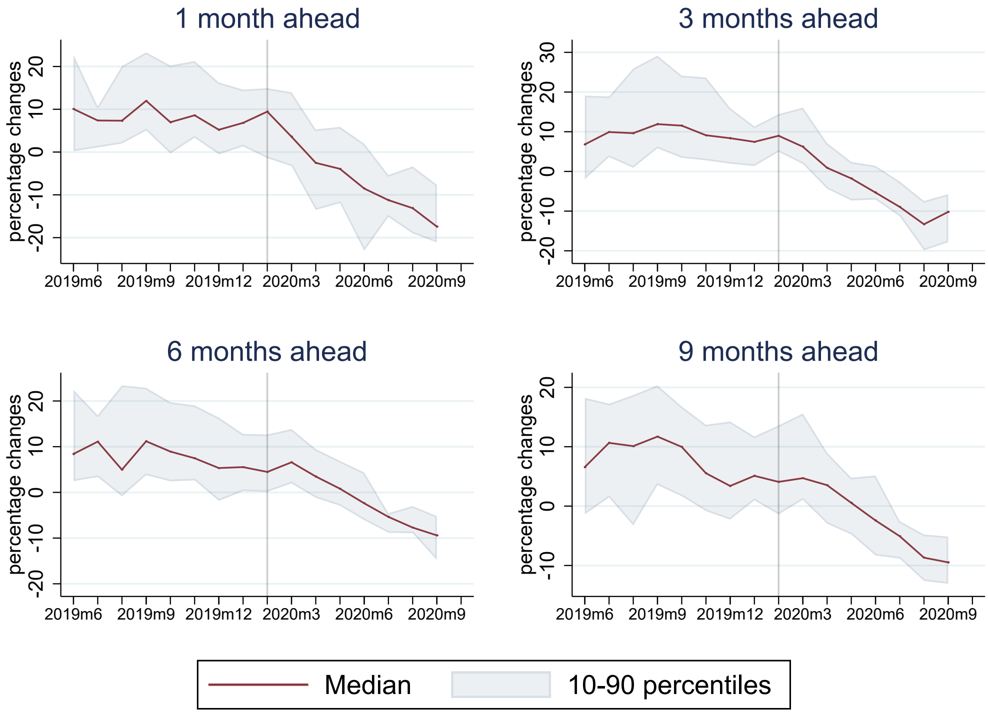
cities (Figure B.3). The impact is visible up to six-months ahead. In the aftermath of the Covid-19 outbreak, the vacancy rate's median increase was about 40 percentage points for one-month ahead reservations and 20 percentage points over a three-month horizon. As expected, the largest increase occurred in the main touristic destinations. The vacancy rate somewhat decreased during summer, although remaining far larger than in 2019 (the median variation was about 20 percentage points for one-month ahead reservations). During the summer months, the vacancy rate in Barcelona was 40 percentage points larger than in 2019.

The insights derived from the vacancy rate are consistent with those coming from the average monthly number of reviews per apartment, which is a proxy of the occupancy rate.[16] This indicator decreased markedly during the lockdown, reaching a median y-o-y reduction of about 60% in April (Figure 3). Subsequently, the indicator improved, especially in July and August, although remaining significantly lower than a year earlier (the median y-o-y percentage variation was -17%). However, the vacancy rate and the average number of reviews measure only the degree of utilization of the apartments offered on the market. By taking into account the simultaneous reduction in the supply of houses (extensive margin), the contraction in the absolute number of bookings was even stronger (Figure B.4). The median reduction in one-month ahead total bookings was about 60% compared to 2019. The effect was significant over all time-horizons, up to 9-months ahead, and more persistent compared to the previous indicators: bookings increased in July and August, but very modestly.

Prices. Before the epidemic, prices were growing markedly in most cities: the median variation

[16]The vacancy rate measures perspective bookings observed at a given date. In this case, the reference month refers to the date of web scraping. However, this indicator can be noisy because data are not always downloaded on the same day of the month. On the opposite, the indicator based on the reviews refers to all the reviews observed in a given month. For this reason, the reviews-based indicator can be more effective in measuring the occupancy rate.

Figure 4: Prices



Note: Y-o-y percentage changes.

was almost 10% y-o-y. In March and April, prices were not significantly affected. Possibly, the hosts considered demand to be largely inelastic, which is reasonable given that the fall in demand was due to both fear of contagion and limitations to mobility imposed by law (Figure 4). However, prices gradually decreased in the following months: the median variation of one-month ahead prices reached -17% y-o-y in September. The Italian and Spanish cities in our sample are those where prices fell the most. In Barcelona, in particular, during the summer months, prices were more than a third lower than in the previous year.

The drop in prices is quite significant, considering the upward trend before the epidemic and given the simultaneous sharp contraction in apartments' supply. Hosts reduced prices markedly up to one year ahead. That is important for two reasons. First, in our observation sample, future prices are excellent proxies for the spot prices in the following months. That is to say that the median price for renting a house in August is similar when posted in May, in July or in August. Second, accommodation prices published on Airbnb are significantly correlated with hotel prices.[17] Therefore, our results have implications beyond the Airbnb marketplace, pointing to a decrease in prices for accommodation services even when health conditions have normalized.

The median price of the apartments available on the market commented so far is affected, by

[17]The correlation between the prices of Airbnb apartments and the price index of accommodation services of the respective countries (taken from Eurostat) is 0.4 in the period under consideration. For Italian cities, for which we have the corresponding price index of accommodation services at the provincial level (computed by the Italian National Statistical Institute), the correlation is 0.6.

construction, by composition effects. We thus build a second indicator, based on price changes for the same apartment in two contiguous months, to take into account the characteristics of the houses offered.[18] In most cities, this quality-adjusted indicator decreased less markedly than the other (Figure B.5). Then, the composition effects contributed negatively to the dynamics of observed prices, implying that the apartments that left the market were on average more expensive than the remaining ones.

4 Quantitative evidence at the city level

4.1 Model setup

Our econometric strategy takes advantage of the different timing and intensity of both the epidemic spread and counteracting containment measures across Europe, as described in the previous Section. For each city, we estimate how prospective indicators of market activity at different horizons varied over time and to what extent the changes observed since March 2020 can be due to either the coronavirus diffusion or the containment policies. We measure the evolution of epidemiological conditions through the average infection rate and Covid-19 ICU per population between two close observation dates.[19] We proxy government containment measures with the average stringency index both for domestic and international travel restrictions.

Isolating the separate contributions of government measures, which limited both domestic and international travels, and of worsening health conditions, that could have reduced people's mobility even in absence of shutdown orders, is challenging. Given that our data are collected at monthly frequency and the sample period affected by Covid-19 is relatively short, we do not claim to achieve a sharp identification of the distinct impact of these two factors. However, the identification problem is mitigated for three reasons. First, some countries delayed the adoption of containment measures, or their intensity was initially low. Second, although data are collected at monthly frequency, the dates of web-scraping usually differ among cities, providing us with additional variation within the same month.[20] Third, as we run this analysis on data up to September 2020, we can observe the effects of the epidemic at the beginning of the second wave of contagion in Europe, when containment measures had not been tightened yet. For a sample of cities we further extend the analysis to early 2021 (see Section 5), thus fully including the new surge of infection in the fall of 2020 and the changes induced by the start of the vaccination campaign. Overall, these sources of heterogeneity allow us to consider jointly the severity of epidemic and the degree of policy tightening within a unique regression framework.

As dependent variables, we consider the number of available houses, the price level (both as

[18]The methodology for estimating this indicator is in the Appendix. One problem with this indicator is that it considers only those apartments on offer in the previous month. As a result, selection effects may bias the indicator.

[19]Due to the poor knowledge of the epidemiological phenomenon at the beginning of the pandemic spread, it is possible that these indicators were subject to a greater measurement error during the first period of the pandemic.

[20]For example, data for Paris and London were scraped on March 15, before the announcement of the national lockdown. The March snapshot is after the outbreak of the epidemic and prior to the lockdown also for other cities. Finally, our sample includes Stockholm, for which government measures were very modest compared to other countries.

median of observed prices and median of the hedonic index), the booking rate, the cancellation rate, and the vacancy rate. For each of these variables, we estimate the following linear regression models:

$$\begin{aligned} Y_{jth} = \alpha_{jmh} + \beta_{1h} INF_{jt} * h + \beta_{2h} ICU_{jt} * h + \beta_{3h} STR_{jt}^{INT} * h + \\ + \beta_{4h} STR_{jt}^{DOM} * h + \gamma \mathbf{X}_{jt} + \varepsilon_{jth} \end{aligned} \tag{1}$$

where Y_{jth} is dependent variable (e.g. the vacancy rate) h-months ahead for city j and data scraped during month t. INF_{jt}, ICU_{jt} and STR_{jt} are the average infection rate, the Covid-19 ICU per population and the stringency index in the country of city j, respectively;[21] as previously argued, we distinguish between domestic (DOM) and international travel (INT) restrictions using the corresponding components of the stringency index. Each variable is interacted with a set of dummies h, one for each time horizon, to obtain a marginal effect varying with the horizon.

For any snapshot of data, we take the average of the epidemiological and stringency over the period between the date of the previous snapshot and the previous day of the current snapshot. We also consider city-month-horizon fixed effects (α_{jmh}), to account for heterogeneity across cities and for monthly seasonal effects specific for each city-horizon pair. Finally, $\mathbf{X}_{jt}$ is a vector of additional control variables, such as the number of total tests per population, the total houses used to compute the dependent variable, the span period between the current and previous snapshots and the decade of the web-scraping date. We do not use controls related to population characteristics since they are indirectly captured by the fixed effects already included in the model.

4.2 Results

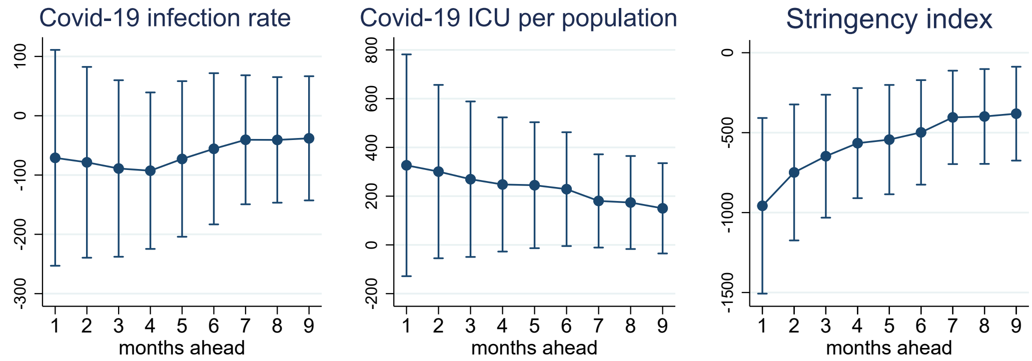
In this section we present the estimates of the coefficients of interest in eq. (1), namely those capturing the effects of the sanitary variables and the stringency index. As previously explained, the empirical strategy gives the possibility to estimate a different impact for any time horizon, up to 9 months ahead the observation date. This feature allows us to distinguish short-term effects (1-2 months ahead) from more persistent ones, more likely influenced by agents' expectations on future developments. We graphically show estimates for our parameters of interest in Figures 5-9, where we plot both point estimates and confidence intervals at 10% level obtained using errors clustered at the city level.[22] The total effect associated to the stringency index combines the domestic and the international component.[23] Our results show that the outbreak of Covid-19 determined a sharp reduction in the supply of short-term rentals; this effect seems more related

[21] Since the data for the two cities may have been scraped at different dates, these variables are different even for cities belonging to the same country.

[22] In interpreting the results and the y-axis of Figures 5-9, one should keep in mind that variables differ by their unit of measure. Therefore, the impact on short-term rentals is represented by absolute numbers; that on cancellation, booking and vacancy rates is measured in percentage points and that on prices (which are taken in logs) as percentage changes.

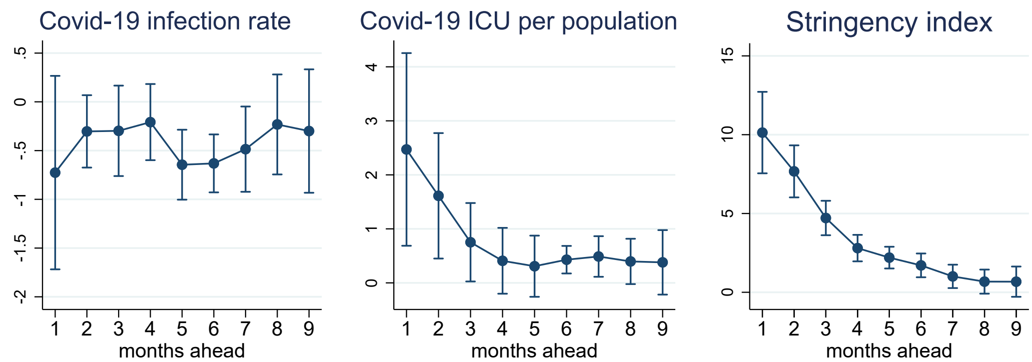
[23] Appendix Figures B.6-B.11 show the separate impact of the domestic and international components of the stringency index.

Figure 5: Effects of linear projection on the supply of short-term rentals



Note: The graph shows the coefficients of the regression of total houses available for rents on sanitary variables and the stringency index for different time horizons. Regressors are standardized. Confidence intervals are at 10% level.

Figure 6: Effects of linear projection on the cancellation rate



Note: The graph shows the coefficients of the regression of cancellation rates on sanitary variables and the stringency index for different time horizons. Regressors are standardized. Confidence intervals are at 10% level.

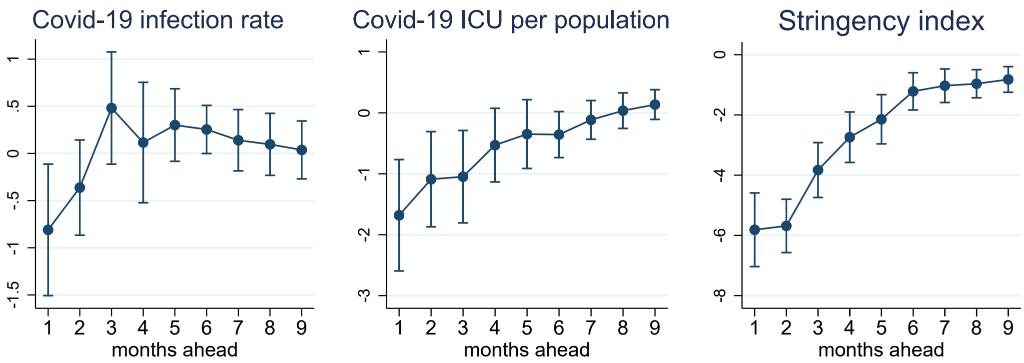
to the restrictions adopted by the governments to fight the epidemic rather than the spread of virus itself (Figure 5). The effect of the stringency index is negative and significant over all time horizons, though becoming smaller over time: the impact 9 months ahead is roughly half that for the short-term. Our estimates imply, for instance, that an increase of the stringency index by 28 points, like that occurred on average in March 2020, is associated with a reduction in supply of about 17% and 7% for one and 9-months ahead, respectively. Our analysis further suggests that these effects are more related to domestic restrictions rather than international ones. This result is possibly due to the fact that domestic restrictions apply to both domestic tourists, which on average represent about half of tourist presences in the countries we consider,[24] and international tourists, who take into account not only the difficulty of accessing a given country but also the possibility of visiting touristic attractions once they have crossed the border.[25]

By considering the combined impact of infection rates and ICU occupancy, we find a strong

[24]Source: Eurostat, nights spent at tourist accommodation establishments by country/world region of residence of the tourist in 2019.

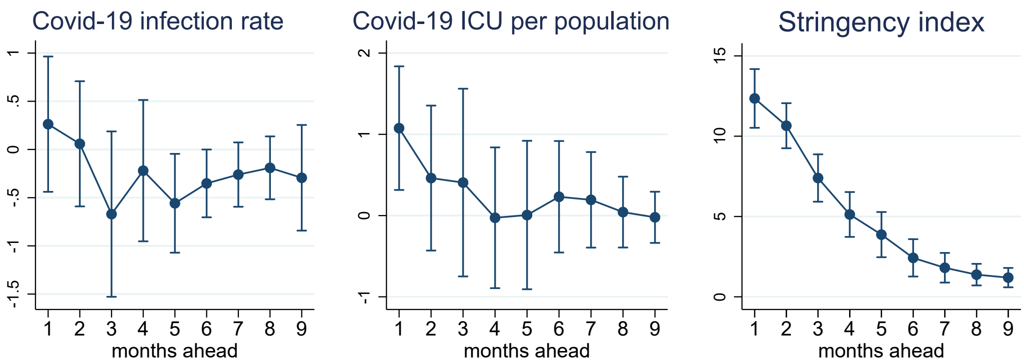
[25]Given the high covariance between STR_{it}^{INT} and STR_{it}^{DOM}, these two components are less significant when taken in isolation. Results about the separate impact of domestic and international restrictions are available upon request.

Figure 7: Effects of linear projection on the booking rate



Note: The graph shows the coefficients of the regression of booking rates on sanitary variables and the stringency index for different time horizons. Regressors are standardized. Confidence intervals are at 10% level.

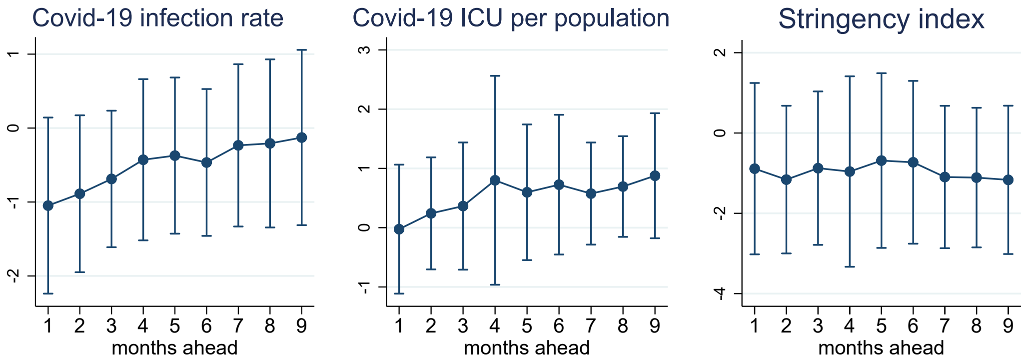
Figure 8: Effects of linear projection on the vacancy rate



Note: The graph shows the coefficients of the regression of vacancy rates on sanitary variables and the stringency index for different time horizons. Regressors are standardized. Confidence intervals are at 10% level.

effect of the pandemic also on the demand for vacation rentals, with an increase in the cancellation rates and a decrease in new bookings (Figures 6-7). The stringency index and ICU occupancy both play an important role; Covid-19 infections, instead, have a negative impact only on new bookings in the very short term. The impact of the stringency index is quite persistent: for the booking rate it remains significant over all time horizons, while cancellations are affected up to 7 months ahead. The impact of health conditions is more short-lived, vanishing for horizons longer than one quarter. To provide an example, consider what happened in March 2020. The one-month ahead cancellation rate increased by about 35 percentage points (from 7 to 43%); according to our estimates, considering only the variables of interest, about 12 points out of 35 were due to government restrictions and 2 points to worsening health conditions. In the same period, the one-month-ahead booking rate halved (to 16%): the rise in the stringency index explains about 6 points of this drop, the variation in ICU occupancy about 0.8 points and the spread in infection another half percentage point. As a result of the reduction in the demand for short-term rentals, the vacancy rate is also positively affected by the stringency index and, in the short-term, by the sanitary situation (Figure 8). As it is the case for the supply, also for the demand of short-term rentals the impact of domestic restrictions seems stronger than that of international controls.

Figure 9: Effects of linear projection on median prices



Note: The graph shows the coefficients of the regression of median prices on sanitary variables and the stringency index for different time horizons. Regressors are standardized. Confidence intervals are at 10% level.

Lastly, the effects on prices are mostly not significant because of the large uncertainty surrounding the coefficients estimates (Figure 9).[26] This result could be due to a delayed reaction of prices, as apparent from the descriptive statistics (Figure 4). Indeed, in the early phase of the pandemic demand was likely not very reactive to prices, because strict lockdowns prevented any mobility and there was high uncertainty regarding the possibility of travelling in the future. As containment measures were eased and households started to plan their summer holidays, owners probably reacted by reducing prices. However, our regression is not able to capture such delayed effects because it includes only contemporaneous variables.

5 Quantitative evidence at the micro level

In the previous Section we have studied the impact of Covid-19 on the short-term rental market by exploiting the heterogeneity in epidemiological conditions and containment measures across European countries. Here we move one step forward by leveraging detailed information at the listing level. This allows us to refine our analysis along two dimensions. First, we can check whether the effects detected at the city level are confirmed when using richer data and controlling for listing specific features. Second, we can investigate to what extent and in which ways the pandemic affected listings presenting different characteristics.

Regarding listing features, we focus on international exposure, defined as the propensity to host foreign tourists before the outbreak of the pandemic. This could be a key aspect not only during the most acute phase of the health crisis but also in the post-pandemic period. Indeed, if foreign-oriented listings have suffered the most from the pandemic, the hosts may have decided to exit from the market of short-term rentals and convert their dwellings to other uses. Looking forward, this may have medium-term repercussions on other segments of the real estate market if hosts decide to put their apartments on sale or to rent them with long-term contracts. Moreover, since in 2020 tourists chose or were forced to travel mainly to domestic destinations, that were reachable more easily and not subject to international travel restrictions,

[26]Appendix Figure B.12 shows the effects on the median hedonic price index.

this attitude may persist also in the future (Shin et al., 2022).

We measure the international exposure of each listing with the share of reviews written in foreign language in the pre-pandemic period. This represents not only a backward-looking measure of the share of foreign tourists who chose a given accommodation in the past but also a forward-looking indicator, given that foreign tourists tend to give more credit to reviews written in their own language. This creates a self-perpetuating segmentation of the market which we observe in the data.

There is no need to have observations for a large number of countries for this analysis. Then, we focus on 21 markets located in Spain, France and Italy[27] for which we are able to run a textual analysis to distinguish whether reviews are written in the domestic language (Spanish, French and Italian, respectively) or in any other language. To identify the language we use two algorithms of the library Google's Compact Language Detection (CLD).[28] For these markets, we also collect data on the evolution of epidemiological conditions – proxied by the number of hospitalizations per 100,000 population – at the local level (Figure B.13b).[29] Hence our measure of international exposure is defined as:

$$INTEXP_i = 1 - \frac{\sum_{t_0}^{2019} reviews\ in\ domestic\ language_i}{\sum_{t_0}^{2019} reviews_i}$$

Based on the value taken by the variable $INTEXP_i$, we can define as foreign-oriented all listings that in 2019 had more than 50% of the reviews written in a foreign language ($INTEXP_i > 0.5$) and domestic-oriented all the other listings that do not satisfy this criterion. Figure 10 shows that there is a substantial heterogeneity in the share of foreign-oriented listings, both within and across markets.

5.1 Model setup

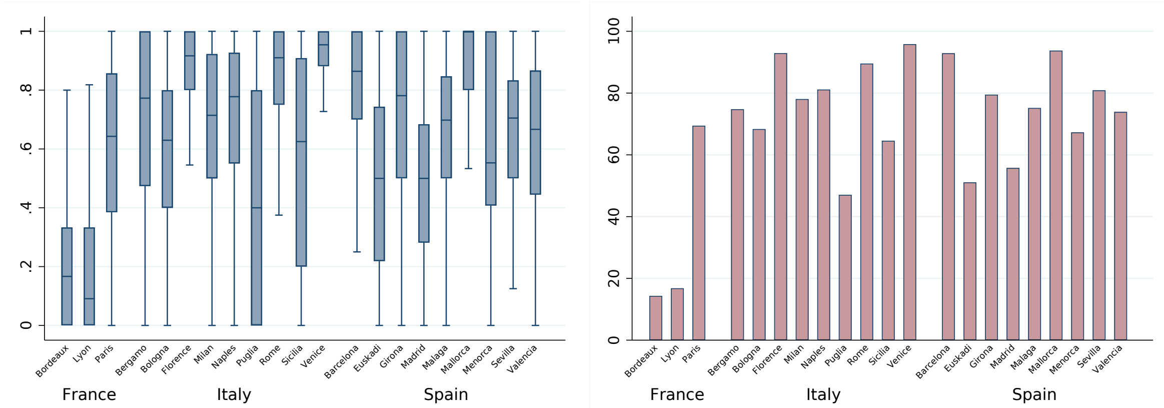
Our econometric strategy aims at quantifying the impact of epidemiological conditions and containment measures controlling for listing and market features. To exploit cross-market heterogeneity within the same country we need to gather information on local epidemiological conditions. Since harmonized data on infection rates (which require data on testing) and ICU occupancy are not available at the sub-national level, we cannot use these variables as in Section 4 and we resort to hospitalization rates in the region where the market is located. Among con-

[27]The markets are: Paris, Lyon and Bordeaux in France; Barcelona, Euskadi, Girona, Madrid, Malaga, Mallorca, Menorca, Sevilla and Valencia in Spain; Bergamo, Bologna, Florence, Milan, Naples, the Puglia region, Rome, the Sicilian region and Venice in Italy. Within those markets we select about half of the listings in the sample, those that were already present in 2019 and with at least 5 reviews.

[28]In particular, we use the CLD2 and CLD3 algorithms. The CLD2 algorithm is a Naive Bayesian classifier. The CLD3 algorithm is a neural network model. Loosely speaking, these are equivalent to the algorithms that are used by Google to automatically detect the language when using Google Translator. In our sample CLD2 and CLD3 algorithms almost always give the same result. In case of discordant results we consider the information about the language to be missing.

[29]For Italy, data are provided by the *Istituto Superiore di Sanità* (ISS, the National Institute of Health). For Spain, data come from the *Instituto de Salud Carlos III* (ISCIII) and can be freely downloaded from the website `https://rubenfcasal.github.io/Covid-19/`. For France, data are publicly provided from the French government at the website `https://www.data.gouv.fr/fr/datasets/synthese-des-indicateurs-de-suivi-de-lepidemie-Covid-19/`.

Figure 10: International exposure of listings in 2019



(a) *International exposure* (b) *Share of listings with high international exposure*

Note: Panel (a) shows the distribution of the variable $INTEXP$ by city in 2019. Panel (b) shows the share of listings that in 2019 had more than 50% of the reviews writtent in a foreign language.

tainment policies, we distinguish between domestic and international travel restrictions, both measured at the national level (Figure B.13a).[30]

As shown in Section 4.2, the pandemic significantly reduced the supply of short-term rentals. Therefore, we adopt a selection model *à la* Heckman (Heckman, 1979) and proceed in two steps. We first estimate the probability that a listing exits the market; then we use this result to control for selection when we estimate the reaction of the other outcomes of interest – booking rates, cancellation rates, vacancies, prices – that can be observed only for those listings that have remained on the market. To apply this procedure we need to focus on a subset of 13 markets for which we have data for the entire sample period.[31]

The econometric model for the first selection step reads as follows:

$$\begin{aligned} e^*_{ijzt} =& \beta_1 \left(Hosp_{jt} * FOR_{i0}\right) + \beta_2 \left(STR^{INT}_{jt} * FOR_{i0}\right) + \beta_3 \left(STR^{DOM}_{jt} * FOR_{i0}\right) + \\ & \gamma_1 \left(Hosp_{jt} * FOR_{i1}\right) + \gamma_2 \left(STR^{INT}_{jt} * FOR_{i1}\right) + \gamma_3 \left(STR^{DOM}_{jt} * FOR_{i1}\right) + \\ & \delta_1 \mathbf{X}_{it} + \delta_2 \mathbf{Z}_{it} + \eta FOR_{i1} + \nu_z + \alpha_m + \epsilon_{ijzt} \qquad (2) \\ e_{ijzt} =& \begin{pmatrix} 1 \text{ if } e^*_{ijzt} > 0 \\ 0 \text{ if } e^*_{ijzt} \leq 0 \end{pmatrix} \end{aligned}$$

[30]To measure domestic and international travel restrictions we take the corresponding components in the Oxford Stringency Index. Both components are measured on a 4-point scale, where 0 corresponds to the absence of restrictions and 4 to the maximum. By definition, international travel restrictions apply to the whole country. Instead, the degree of restrictions to domestic travels could at times vary across the national territory but we do not take that into account. Besides the lack of reliable and harmonized data on local restrictions, it is not clear that they would improve our identification strategy compared to national-level data. Ideally, one would like to control for the degree of restrictions both in the origin and destination of the trip but our data do not allow us to infer the origin of the tourist (in some cases we can at most infer the country through the language of the review).

[31]A listing is considered to have exited the market if it does not appear any more on the website for at least 60 days. Hence, we cannot estimate the exit probability in a given market if two or more consecutive months of data are missing. The 13 markets for which we can estimate the probit model are Paris, Lyon and Bordeaux in France; Barcelona, Madrid, Mallorca and Valencia in Spain; Bologna, Florence, Milan, Naples, Rome and Venice in Italy.

In equation (2) the probability that listing i in location j, zip code z exits the Airbnb market at time t depends on several listing and market specific characteristics. The variable FOR_{i1} is a dummy variable that denote listings traditionally oriented towards foreign tourists according to the above mentioned definition; correspondingly, FOR_{i0} takes value 1 for domestic-oriented listings. We allow epidemiological conditions in market j – captured by the average daily number of new hospitalizations (normalized by the local population) in the reference month ($Hosp_{jt}$) – and containment measures – STR_{jt}^{DOM} and STR_{jt}^{INT} for domestic and international travel restrictions, respectively – to have different effects depending on the international exposure of the listing.[32] In our full specification we also control for other listing specific characteristics ($\mathbf{X}_{it}$), either fixed or time varying, such as the property type (hotel or private accommodation), the room type (apartment or shared room), the number of bathrooms, the cancellation policy and the review score. In vector $\mathbf{Z}_{it}$ we include the characteristics of the host (how long he has been offering short-term rentals on the Airbnb platform, how many accommodation he handles and whether he is classified as a superhost), which may influence his propensity to leave the market but not so much the other outcomes of interest.[33] Finally, we include zip codes fixed effects (ν_z) and dummy variables for each calendar month (except the first one), denoted by α_m, to control for potential seasonal effects.

In the second step we estimate the effects of epidemiological conditions and containment measures on the demand and prices of the listings remaining on the market, controlling for selection:

$$\begin{aligned}y_{ijzth} =& \beta_{1h} \left(Hosp_{jt} * FOR_{i0} * h\right) + \beta_{2h} \left(STR_{jt}^{INT} * FOR_{i0} * h\right) + \beta_{3h} \left(STR_{jt}^{DOM} * FOR_{i0} * h\right) + \\ & \gamma_{1h} \left(Hosp_{jt} * FOR_{i1} * h\right) + \gamma_{2h} \left(STR_{jt}^{INT} * FOR_{i1} * h\right) + \gamma_{3h} \left(STR_{jt}^{DOM} * FOR_{i1} * h\right) + \\ & \delta \mathbf{X}_{it} + \eta FOR_{i1} + \nu_z + \alpha_{jth} + \lambda(e) + \varepsilon_{ijzth} \end{aligned} \tag{3}$$

where h denote the horizon (from 1 to 9), α_{jth} are market-month-horizon fixed effects and $\lambda(e)$ is the inverse Mills ratio derived from the probit model that controls for selection; the host's characteristics $\mathbf{Z}_{it}$ are excluded. Standard errors are clustered at the market level.[34] To verify the robustness of our distinction between domestic and foreign-oriented listings, we also estimate models (2) and (3) by replacing the dummy variables FOR_{i0} and FOR_{i1} with the continuous indicator of international exposure INT_i. By using this alternative measure results are broadly confirmed but for the sake of exposition we will focus on our baseline dichotomous specification.

5.2 Results

Let us first consider the results of the probit model described by equation (2) and summarized in Table A.2. Focusing on column (4), which is based on the dichotomous distinction between

[32] To avoid collinearity STR_{jt}^{INT} is included in deviation from the the domestic component.

[33] Airbnb users only know whether a host is classified as superhost. However, in this context, this variable is used, together with the other two host's characteristics, to capture how involved is the host in the rental activity.

[34] In a robustness check we cluster standard errors at the market-month level and results are virtually unchanged. Other robustness involve the estimation of (2) and (3) without some control variables; results are available upon request.

domestic and foreign-oriented listings and includes month and zip code fixed effects and listing characteristics, we find that in absence of Covid-19 hospitalizations and containment measures the exit probability is lower for foreign-oriented listings (first row) and for listings managed by hosts who conduct this activity on a routine basis (variables *Hosting old*, *Listings count* and *Superhost*). Restrictions to internal movements increase the probability of exit, more for listings with high international exposure than for the others: a one-point rise in the index of domestic restrictions increases the exit probability by 6.5% for domestic-oriented listings and by 16% for foreign-oriented ones. More stringent restrictions to international travels compared to those on internal movements determine an increase in the exit probability by more than 7%, without much difference across listing types. Epidemiological conditions, unexpectedly, reduce the exit probability, although only slightly so (by around 3 and 5% for domestic and foreign-oriented listings, respectively). This is probably due to many hosts deciding to withdraw from the Airbnb platform during the summer months of 2020, when hospitalizations were low.[35] Results are not strongly affected, neither qualitatively nor quantitatively, by the inclusion of different controls (columns 1-4). Columns (5)-(8) report the results of an alternative specification based on the continuous measure of international exposure $INTEXP$. These outcomes confirm that foreign-oriented listings are on average less likely to exit the market (negative coefficient on $INTEXP$) but react more to both domestic and international restrictions.[36]

Then we move to analyse the impact of the pandemic on the other outcomes of interest, controlling for selection, as described by equation (3). Descriptive statistics for the variables of interest at the one month-ahead horizon in different sub-samples are provided in Table A.1. Like in Section 4.2, we show how the coefficients of interest vary with the time horizon, distinguishing the impact on domestic and foreign-oriented listings (Figures 11-14).[37]

Domestic restrictions induced many customers to cancel their reservations and stopped them from making new ones. A one-point rise in the stringency index related to internal movements, like that seen on average in March 2020, more than doubles two-months-ahead cancellation rates, leading to an increase of 5 percentage points for domestic-oriented listings and 10 percentage points for listings with high international exposure, whereas the average cancellation rate in the pre-pandemic period was about 3% (Figure 11). At the same time domestic restrictions halve one-month-ahead booking rates (the impact is about -10 percentage points, which compares to an average booking rate of 25% in the pre-pandemic period; Figure 12). Although they shrink with the time horizon, these effects are quite persistent and remain significant up to 6 months ahead and in some cases even longer. More cancellations and less bookings imply an increase in vacancies by 2(4) nights for domestic-(foreign-)oriented listings at one-month-ahead horizon. Considering that the median vacancies one-month ahead in the pre-pandemic period was equal to 13 nights, this represent an increase of about 15(30)%. This impact, however, is short-lived:

[35] See Appendix Figure B.14.

[36] Notice that in columns (5)-(8) we only include stringency indexes and daily hospitalizations in interaction with $INTEXP$, because non-interacted variables correspond to the special case of $INTEXP = 1$.

[37] Notice that Figures 11-14 represent the reaction of the outcomes of interest to a one-point rise either in restrictions or in hospitalization per 100,000 population. The estimated coefficients for city-level regressions (Figures 5-9) refer instead to standardized regressors because their scale was very different and it would have been hard to compare their magnitude.

at longer horizons we find a slight reduction in vacancies, suggesting that some tourists might have decided to postpone their reservations. The impact of international travel restrictions is considerably smaller and becomes significant only at longer horizons (from 6 to 9 months ahead).

Epidemiological conditions have a significant impact in the short-term but overall magnitudes are smaller compared to those of containment measures. The strong rise in hospitalizations observed in March 2020 (about 2.3 points) implies an increase in one-month-ahead cancellation rates by about 4 percentage points and an even stronger reduction in booking rates. However the impact on cancellation rates is very short-lived. The effect on vacancies is much smaller (about half night) but more persistent compared to that of travel restrictions.

Finally, we find that the pandemic induced some price changes for foreign-oriented listings but not for listings with low international exposure. In response to a one-point rise in domestic restrictions, prices decline by around 4%. The central estimate of the reduction in prices is quite persistent but becomes smaller and not statistically significant from the three-months-ahead horizon onward. These effects are only partially counterbalanced by the upward pressures of worsening health conditions. For instance, in September 2020 the median stringency for domestic travels increased by 0.8 points, pushing prices down by 3%, but the overall effect was reduced by half by the spread of the infection (hospitalizations rose by 0.4 percentage points). Overall, our findings suggest that the outbreak of the pandemic acted on foreign-oriented listings as a negative demand shock, inducing hosts to lower prices to attract customers.

To sum up, we find that: i) restrictions on internal movements have the largest effects; ii) the impact of the additional restrictions on international travels is less precisely estimated and often insignificant; iii) epidemiological conditions are statistically significant but magnitudes are smaller; iv) the reaction of foreign-oriented listings is generally stronger along many dimensions.

Figure 11: Cancellation rates

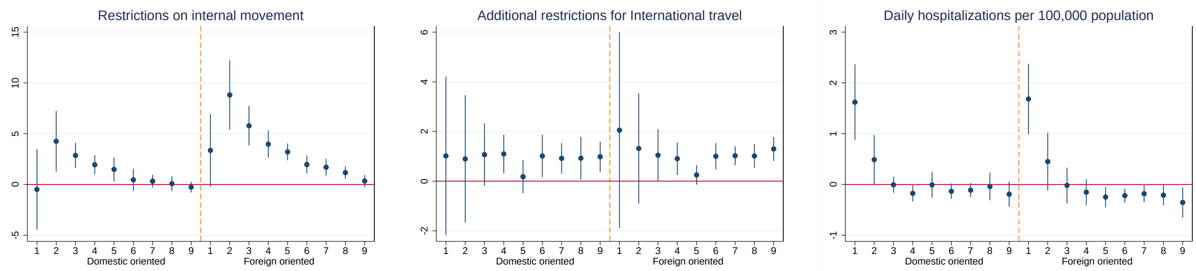


Figure 12: Booking rates

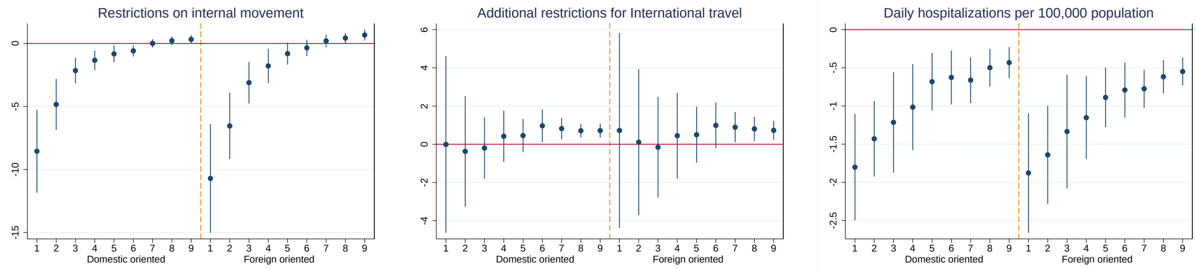


Figure 13: Vacancies

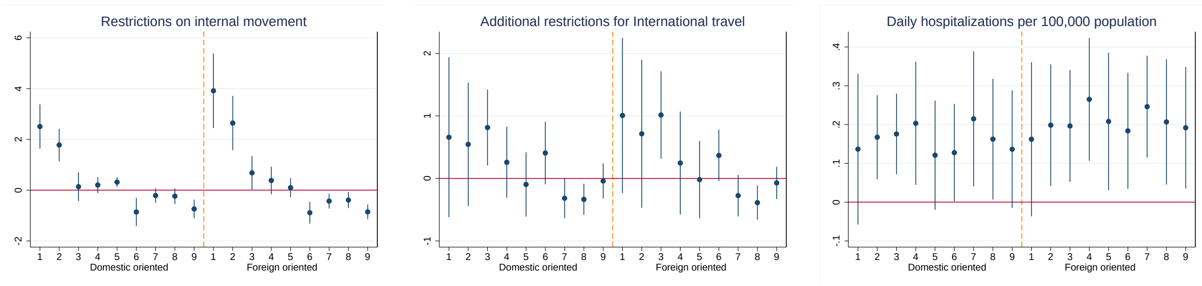
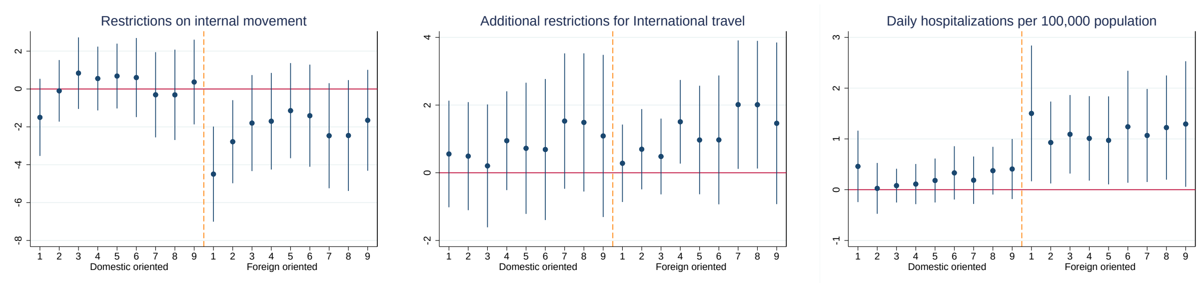


Figure 14: Price variation



5.3 Beyond the short-term: how things did (or did not) change with the arrival of the vaccines

In this Section we extend the sample period under consideration up to April 2021 to study the changes in short-term-rental markets one year into the pandemic. In our analysis we allow the pandemic outbreak to have different effects in 2020 and early 2021, as the start of the vaccination campaign in January 2021 represented a milestone of the fight against the virus and may have radically changed customers' behavior. The vaccination campaign, however, needed some time to take off so that its effects in early 2021 would be mostly due to an increase in people's confidence. Indeed, during the same period European countries witnessed a new surge in Covid-19 infections (Figure B.13b), also linked to the spread of more contagious variants of the virus (like the Delta variant). The reaction to this new wave of contagion, however, was different from that of the early stages of the pandemic as governments did not enact full nationwide lockdowns (Figure B.13a). Moreover, a certain "Covid fatigue"may have changed people's behaviors, irrespective of government-mandated restrictions. All these elements could have played a role in shaping the response of the tourism sector.

To integrate our analysis we first re-estimate the probit model (2) up to February 2021 to control for selection.[38] Then we extend model (3) to allow differential effects for the period before and after the introduction of the vaccine (up to December 2020 and from January to April 2021, respectively).[39]

[38] To estimate the probit model we exclude the last two months of the sample period for which we are not able to identify the listings that leave the market.

[39] For the pre-vax period, Figures 15-18 can slightly differ from Figures 11-14 because the sample period includes also the months from October till December 2020.

First, we find that the impact of domestic restrictions on cancellations, booking rates and vacancies either vanishes or reduces by half and becomes less persistent (Figures 15-18). The negative impact on the prices of foreign-oriented listings is instead confirmed. International travel restrictions, which are mostly not significant in 2020, assume instead a significant role in early 2021 but only for booking rates and therefore for vacancies. Rising international travel restrictions by one point – holding constant those to internal movements – determines a reduction in booking rates by 4 percentage points and an increase in vacancies by 2 nights. The effects are similar for listings with different international exposure and have approximately the same magnitude up to five months ahead; then the size of the impact gets smaller but coefficients remain mostly significant. Prices do not seem to be significantly affected by international travel restrictions. Finally, after the introduction of the vaccine the effects of epidemiological conditions are much more uncertain and mostly not significant. This likely reflects the counteracting forces acting in the first months of 2021: on the one side, the peak in infections which further limited people's mobility, on the other the gradual unfolding of the vaccination campaign and increased optimism. In summary, the introduction of the vaccine altered substantially the outlook of short-term rental markets. Our results suggest that the concerns for infection risks decreased while the accommodation sector was still affected by containment measures, especially those imposing limits to cross national borders. This may also indicate a shift in households' preferences, with a gradual return to travel but mainly towards domestic destinations.

Figures B.15-B.18 in the Appendix show the same results for an analogous model that does not take into account the probability of exiting the market and can thus be estimated over the full sample (21 markets). Results are broadly confirmed, indicating that selection effects do not confound estimates for most of the outcomes of interest.

Figure 15: Cancellation rates

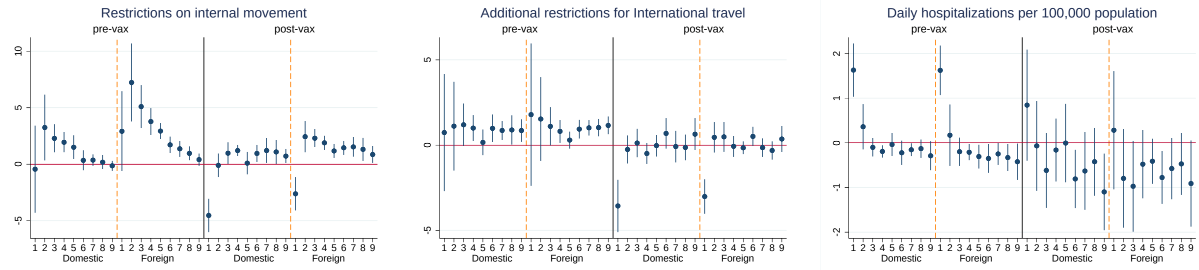


Figure 16: Booking rates

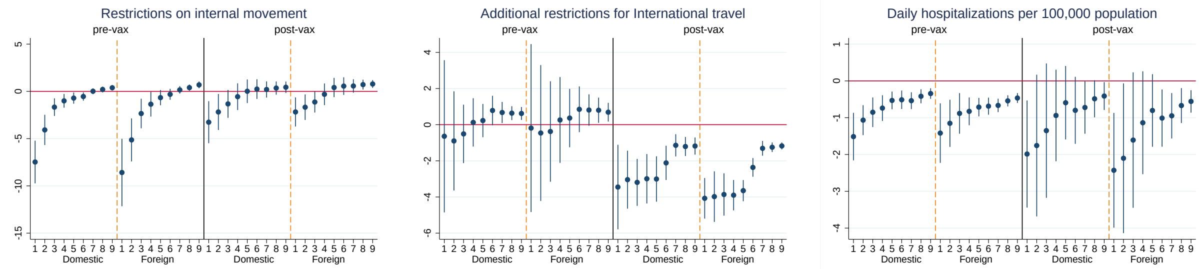


Figure 17: Vacancies

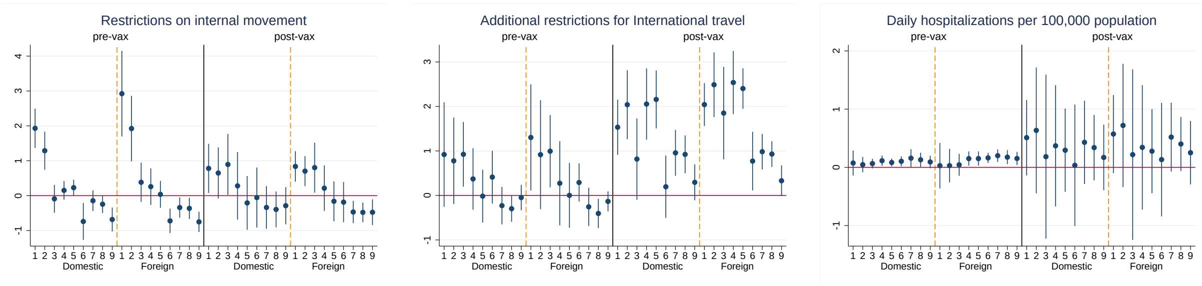
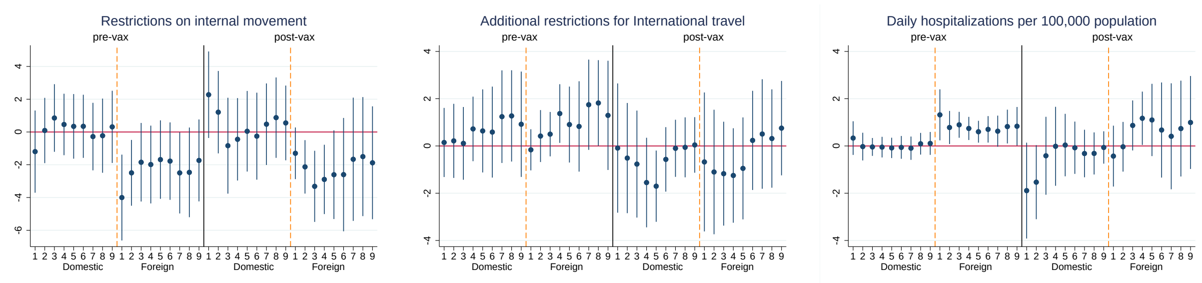


Figure 18: Price variation



6 Conclusions

This work exploits data on the market for vacation rentals to investigate the impact of Covid-19 on customers' behavior and expectations regarding travel and tourism-related activities. This market provides an ideal setting for addressing this issue, since we have data on supply, demand and prices at different time horizons, allowing us to distinguish the short and the medium run effects. We find that the pandemic and the related containment measures strongly reduced both the supply of apartments available for rent and households' demand, even up to 9 months ahead. We also show that the impact of the pandemic has been heterogeneous, affecting to a higher degree accommodations that were *ex ante* more exposed to foreign tourists. For these listings we detect a drop in asked prices, suggesting that the pandemic resembles more a demand shock rather than a supply shock and its effects could be quite persistent.

The start of the vaccination campaign at the beginning of 2021 spread confidence among European households and induced a partial normalization of the market for short-term rentals. Looking ahead however, there could be long-lasting legacies of the pandemic, such as a lower supply of touristic accommodations and an increased attitudes of households' towards domestic tourism. Should these trends be confirmed, there could be consequences on the whole tourism sector, given that foreign tourists have different preferences and usually higher expenses compared to domestic ones, and on real estate markets, as apartments previously used for short-term rentals could be converted to other uses.

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Appendix

A Indicators and descriptive statistics

Below we describe the methodology underlying the indicators presented in the main text.

Cancellation rate. We can only observe if a given apartment is available or unavailable for booking on a given day. Then, we estimate cancelled reservations based on the number of newly available slots for reservations compared to the previous month. To compute the indicator for the month T, we consider listings present both in the snapshot for month T and the snapshot for month $T-1$. For each listing, we observe the calendar both at time T and $T-1$, and we compute the number of days that at time T are available for reservation out of those that at time $T-1$ were unavailable. We compute for each listing the ratio between the newly available slots for reservations at time T and the number of unavailable slots at time $T-1$. For the analysis conducted at the city level presented in Section 4 we then take the average ratio across all listings. We consider a ratio instead of the absolute number of cancellations to smooth out seasonal patterns. Finally, we partition future dates on the calendar in different months (30 days period) starting from day T, and we compute the indicator for different time horizons. For example, we compute the share of cancelled bookings five months ahead by considering the number of newly available slots between 120 and 150 days since day T out of those that were unavailable for the same days at time $T-1$.

Booking rate. The methodology underlying the estimation of new bookings is the same used to estimate cancellations, but we consider the number of newly unavailable slots at time T out of those that were available at time $T-1$.

Vacancy rate. We compute the daily share of available slots for reservations across all listings. Then, we partition the calendar in different months (30 days period) starting from day T, and we compute the average for each period.

Occupancy rate. Although we cannot observe *ex post* how many days guests have occupied a listed house, we can figure out the evolution of the occupancy rate by using guests' reviews. Airbnb urges guests to give their opinion on their stay within 14 days after checking out; beyond this time, it is no longer possible to provide a review. Since hosts are not professionals, guest reviews are essential for this market to work; otherwise, it would become a "lemon"market. As a result, Airbnb sends several reminders to users to leave their review: according to Airbnb estimates, users review 75% of their stays. Reviews allow tracking the number of stays across different months (with a potential 14 days' lag) in the same city. In particular, we compute for each listing the number of monthly reviews. For the analysis conducted at the city level presented in Section 4 we then take the average across all listings.

Unfortunately, we cannot use reviews to compare the occupancy rate across cities because the average period of stay is different, as the reasons why people travel to that city. For example, we expect the average monthly number of reviews per listing to be higher in Venice than in Milan. In the first case, guests are mostly tourists staying in the city for a limited time. In the second case, guests may be workers temporarily moving to the city for job-related reasons, and their period of stay could be longer than for tourists.

Oxford Stringency Index (sub-components). As described by Petherick et al. (2020), the Stringency Index at a given date is the average of 9 sub-indices, each taking a value between 0 and 100: $I = \frac{1}{9}\sum_{j=1}^{9} I_j$. For the analysis conducted at the city level presented in Section 4, among the 9 sub-indices, we separately consider the one referring to international travel controls (STR_{it}^{INT}) and compute the residual one, which captures domestic restrictions (STR_{it}^{DOM}), using the following relationship: $I = \frac{1}{9}\left(\sum_{j=1}^{8} I_j^{DOM} + STR_{it}^{INT}\right)$. By defining $STR^{DOM} = \frac{1}{8}\sum_{j=1}^{8} I_j^{DOM}$, we get: $STR^{DOM} = \frac{9}{8}\left(I - \frac{1}{9}STR_{it}^{INT}\right)$.

For the micro-level analysis presented in Section 5 we only consider the sub-components related to restrictions on internal movements and that related to international travel restrictions, both measured on a 4-point scale where 0 corresponds to zero restrictions and 4 is the maximum attainable level. In the econometric models, restrictions to international travels are included in deviation from the the domestic component to avoid collinearity.

Prices. We compute for each listing the average price in euro at different time horizons, as explained above. We consider only prices for dates that are available for booking. For the analysis conducted at the city level presented in Section 4 we then compute the average across listings. To control for composition effects, we build an additional indicator using the following procedure. For each snapshot, we use only the listings that were present in the previous snapshot. For each listing, we calculate the price variation over all time horizons compared to the previous snapshot. Then, we calculate the median percentage change for each time horizon. Finally, we use these variations to build a price index recursively.

Table A.1: Descriptive statistics on 21 markets located in Spain, France and Italy (one month-ahead horizon)

Variables	Obs	Mean	Min	Median	Max	Sd	Skewness	Kurtosis
				12-2018 1-2020				
Vacancy rate	3974541	13.94	0.00	13.00	30.00	11.02	0.17	1.53
Booking rate	3247996	0.25	0.00	0.14	1.00	0.29	1.02	2.99
Cancellation rate	2710998	0.03	0.00	0.00	1.00	0.12	5.23	34.85
Price	5136574	85.80	3.00	61.00	22171.00	148.95	37.21	2816.73
Hospitalizations	5138054	0.00	0.00	0.00	0.04	0.00	11.10	135.67
Domestic restrictions	5138054	0.00	0.00	0.00	0.00	0.00	.	.
International restrictions	5138054	0.01	0.00	0.00	0.42	0.05	7.89	63.26
				2-2020 12-2020				
Vacancy rate	1672193	18.40	0.00	23.00	30.00	11.53	-0.61	1.74
Booking rate	1345920	0.14	0.00	0.03	1.00	0.25	2.23	7.09
Cancellation rate	1190847	0.14	0.00	0.00	1.00	0.30	1.95	5.30
Price	2145846	91.44	3.00	62.00	17488.00	209.21	25.88	923.61
Hospitalizations	2215345	1.66	0.00	0.71	19.21	2.46	2.60	10.76
Domestic restrictions	2215345	1.35	0.00	1.55	2.00	0.65	-0.55	2.04
International restrictions	2215345	2.71	0.00	3.00	4.00	0.84	-1.86	7.14
				1-2021 4-2021				
Vacancy rate	510083	18.34	0.00	25.00	30.00	12.05	-0.65	1.66
Booking rate	390264	0.12	0.00	0.03	1.00	0.24	2.65	9.19
Cancellation rate	403917	0.02	0.00	0.00	1.00	0.13	5.86	37.79
Price	713920	85.93	7.00	58.00	16766.00	223.57	27.67	944.26
Hospitalizations	713923	2.31	0.23	1.95	8.36	1.45	1.21	4.43
Domestic restrictions	713923	1.72	0.00	2.00	2.00	0.68	-1.98	4.97
International restrictions	713923	3.00	3.00	3.00	3.00	0.00	.	.
				12-2018 4-2021				
Vacancy rate	6156817	15.52	0.00	16.00	30.00	11.45	-0.10	1.43
Booking rate	4984180	0.21	0.00	0.07	1.00	0.28	1.35	3.79
Cancellation rate	4305762	0.06	0.00	0.00	1.00	0.19	3.61	15.56
Price	7996340	87.33	3.00	61.00	22171.00	174.55	32.02	1698.48
Hospitalizations	8067322	0.66	0.00	0.00	19.21	1.63	4.05	24.21
Domestic restrictions	8067322	0.52	0.00	0.00	2.00	0.80	1.07	2.34
International restrictions	8067322	1.01	0.00	0.00	4.00	1.41	0.74	1.68

Note: The markets are: Paris, Lyon and Bordeaux in France; Barcelona, Euskadi, Girona, Madrid, Malaga, Mallorca, Menorca, Sevilla and Valencia in Spain; Bergamo, Bologna, Florence, Milan, Naples, the Puglia region, Rome, the Sicilian region and Venice in Italy.

Table A.2: Probability of exiting the market (probit model)

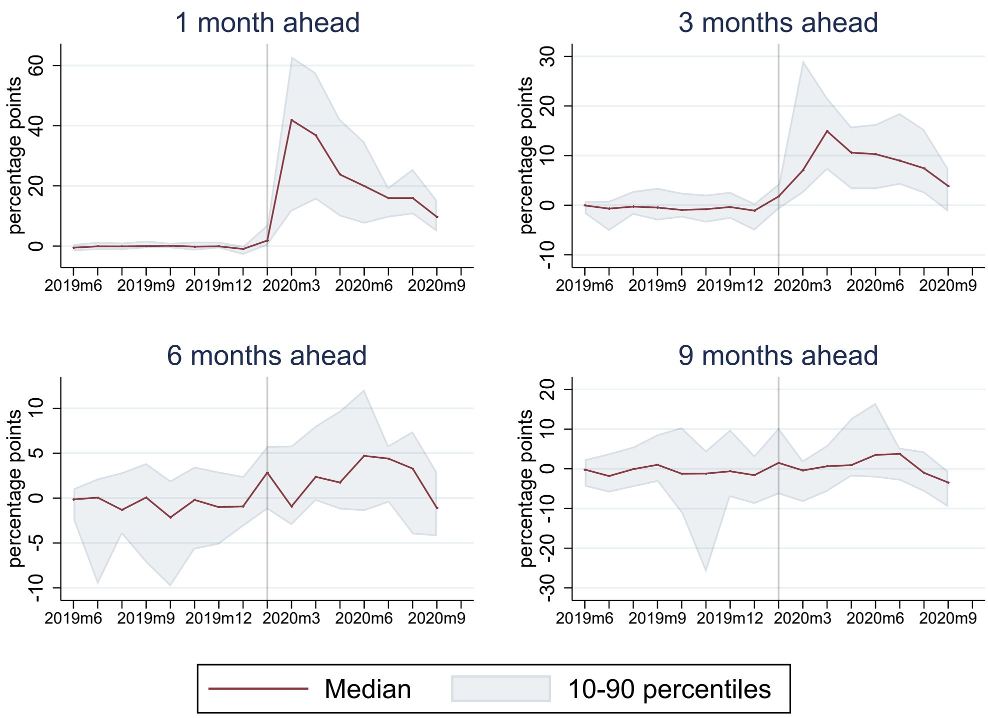
	Market	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Foreign	-0.0975***	-0.0750**	-0.0495***	-0.0541***				
		(0.01)	(0.02)	(0.00)	(0.00)				
Restr. internal movements	Domestic	0.0183	0.0600***	0.0810***	0.0655***				
		(0.30)	(0.00)	(0.00)	(0.00)				
	Foreign	0.1000***	0.143***	0.165***	0.160***				
		(0.00)	(0.00)	(0.00)	(0.00)				
Restr. international movements	Domestic	0.0839***	0.0896***	0.0862***	0.0733***				
		(0.00)	(0.00)	(0.00)	(0.00)				
	Foreign	0.0873***	0.0815***	0.0775***	0.0751***				
		(0.00)	(0.00)	(0.00)	(0.00)				
Daily hospitalizations	Domestic	-0.0185*	-0.0199*	-0.0256**	-0.0293***				
		(0.06)	(0.06)	(0.02)	(0.00)				
	Foreign	-0.0326***	-0.0329***	-0.0445***	-0.0485***				
		(0.01)	(0.01)	(0.00)	(0.00)				
INTEXP						-0.208***	-0.192***	-0.156***	-0.147***
						(0.00)	(0.00)	(0.00)	(0.00)
Restr. internal *INTEXP						0.120***	0.165***	0.190***	0.186***
						(0.00)	(0.00)	(0.00)	(0.00)
Restr. international *INTEXP						0.103***	0.0938***	0.0896***	0.0877***
						(0.00)	(0.00)	(0.00)	(0.00)
Daily hospitalizations* INTEXP						-0.0413***	-0.0385***	-0.0519***	-0.0576***
						(0.01)	(0.01)	(0.00)	(0.00)
Hosting old		-0.00186***	-0.00189***	-0.00172***	-0.00137***	-0.00169***	-0.00170***	-0.00154***	-0.00124***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Listings count			-0.000289	0.00000939	-0.0000780		-0.000259	0.0000147	-0.0000773
			(0.20)	(0.96)	(0.61)		(0.24)	(0.94)	(0.61)
Superhost			-0.263***	-0.247***	-0.186***		-0.256***	-0.242***	-0.182***
			(0.00)	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)
_cons		-1.957***	-1.713***	-1.638***	-0.349***	-1.894***	-1.654***	-1.590***	-0.304***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
	time FE	x	x	x	x	x	x	x	x
	zip code FE			x	x			x	x
	Acc. charact.				x				x
	size								
	Pseudo-R^2	0.00778	0.0204	0.0339	0.0432	0.00753	0.0196	0.0328	0.0424
	Obs.	4428416	4424992	4410463	3397453	4428416	4424992	4410463	3397453

Note: p-values in parenthesis.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The variables included in the accommodation characteristics (Acc. charact.) are: the property type (apartment or single-family home), the room type (entire house or shared room), the number of bathrooms, the guests' rating and the type of cancellation$_policy$.

B Additional figures

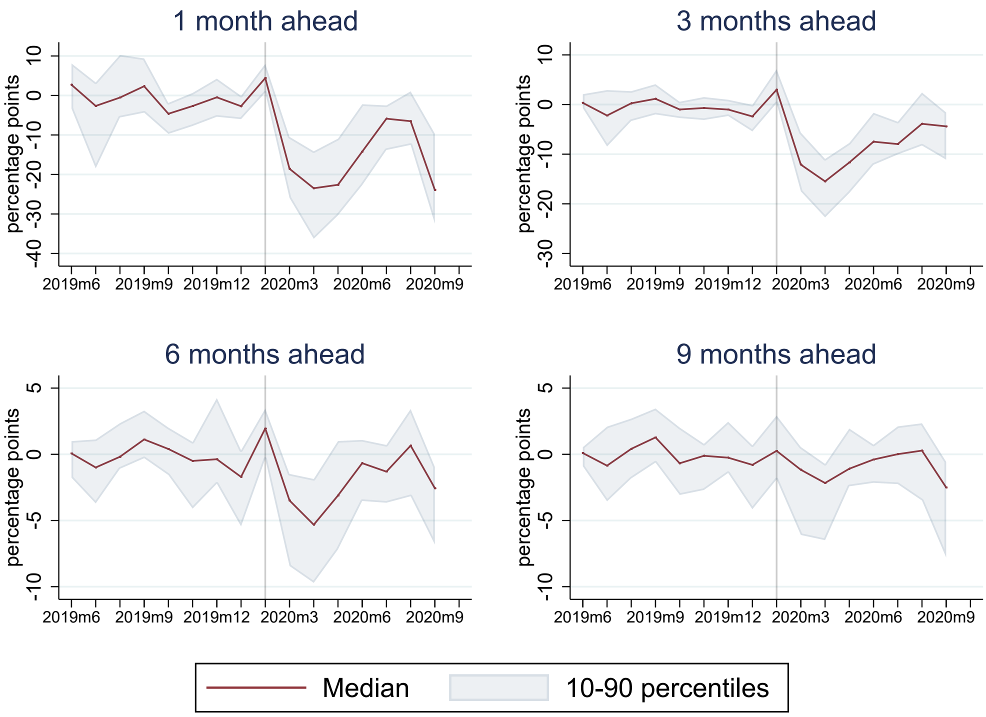
B.1 Stylized facts

Figure B.1: Cancellation rates



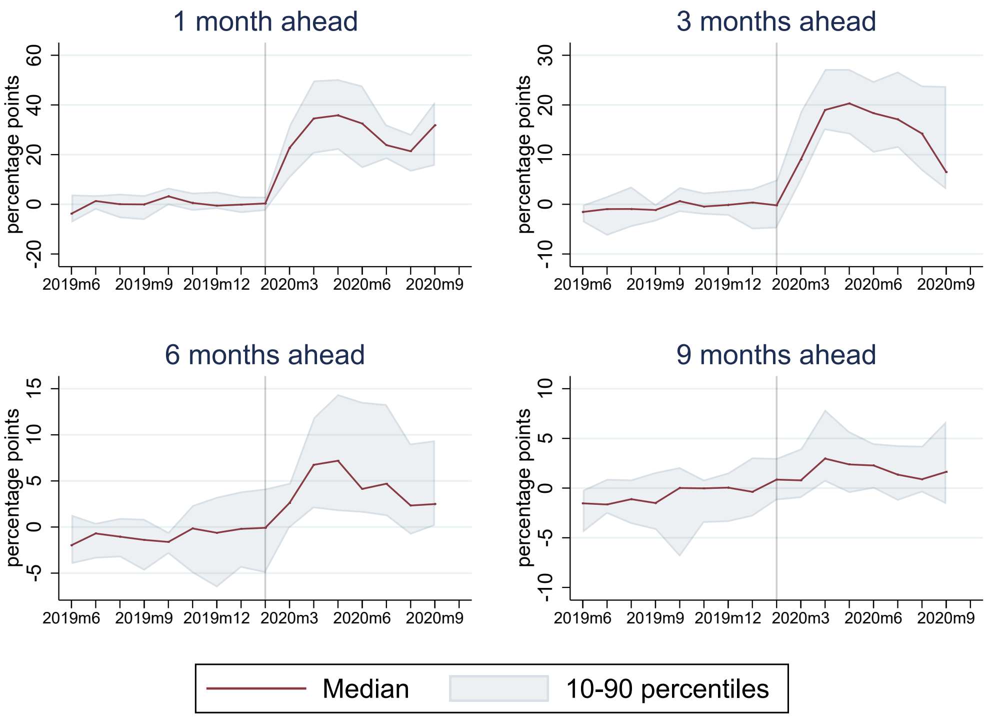
Note: Absolute differences compared to the previous year (percentage points).

Figure B.2: Booking rates



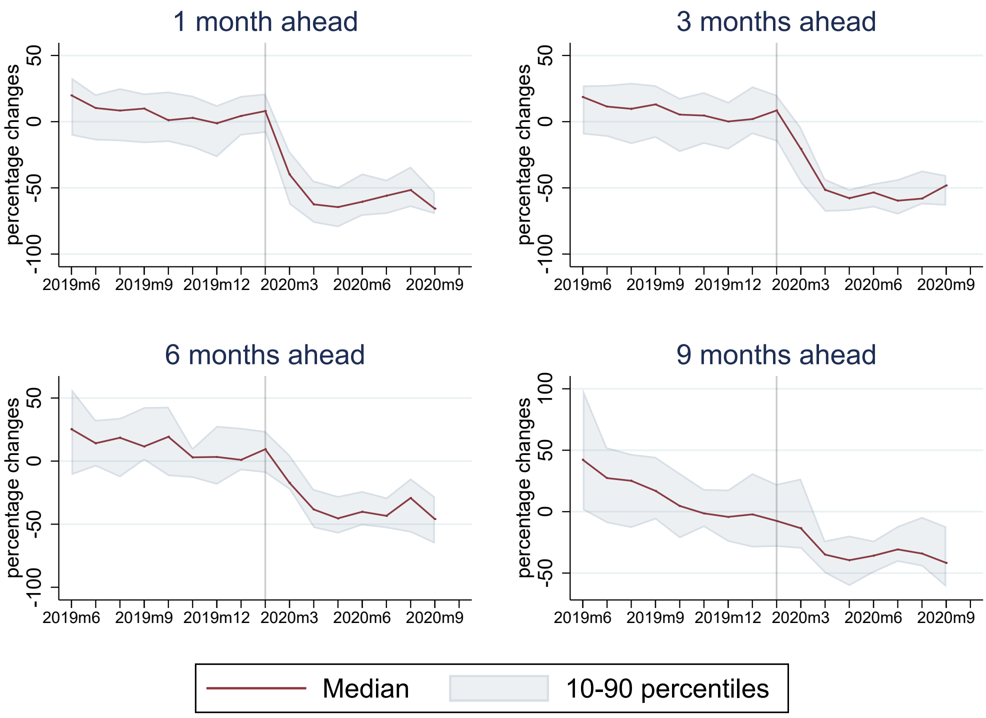
Note: Absolute differences compared to the previous year (percentage points).

Figure B.3: Vacancy rates



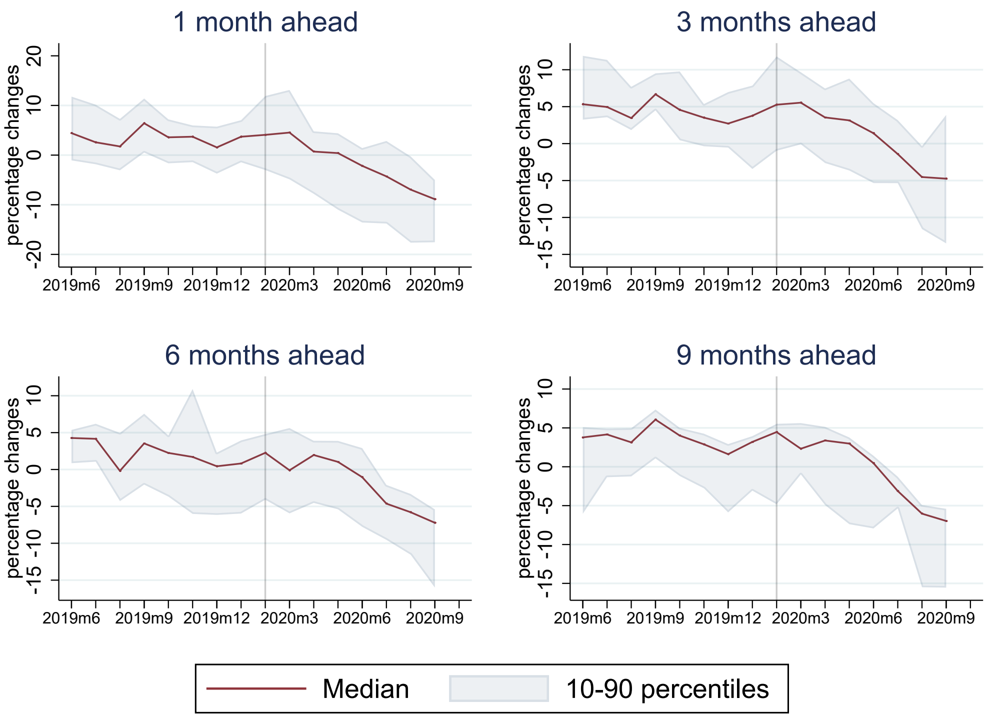
Note: Absolute differences compared to the previous year (percentage points).

Figure B.4: Total bookings



Note: Y-o-y percentage changes.

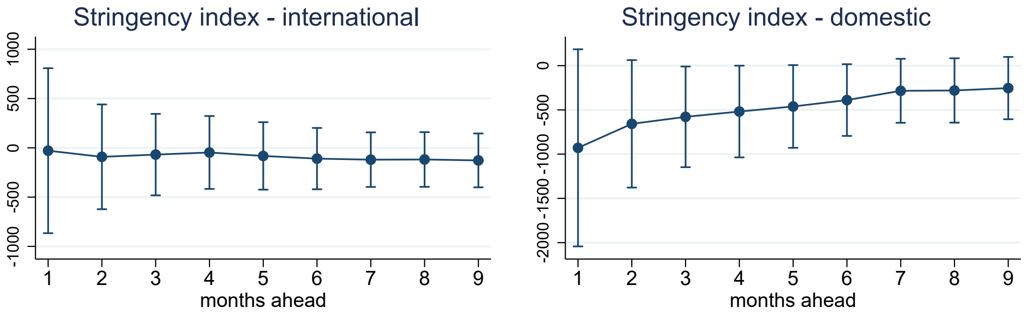
Figure B.5: Hedonic prices



Note: Y-o-y percentage changes.

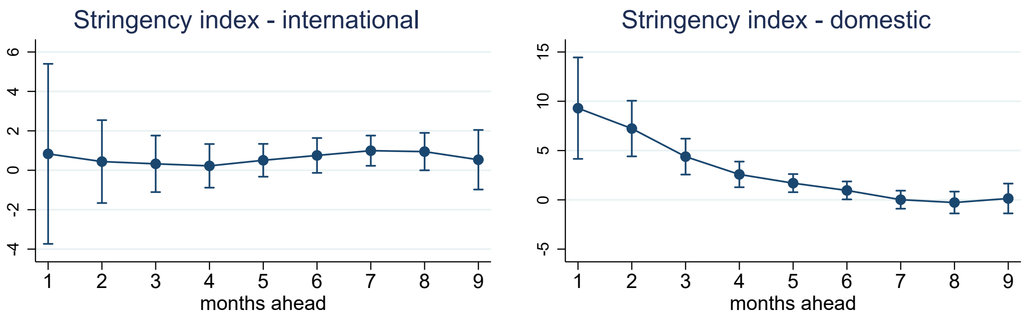
B.2 Quantitative evidence at the city level

Figure B.6: Effects of domestic and international restrictions on the supply of short-term rentals



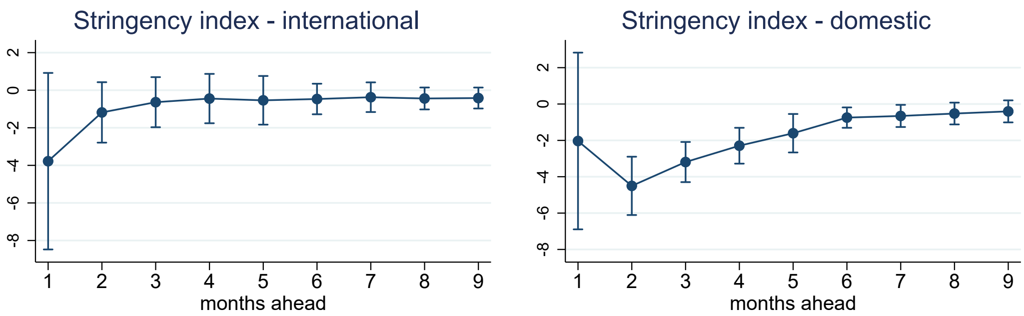
Note: The graph shows the coefficients of the regression of the supply of short-term rentals on domestic and international restrictions for different time horizons. Regressors are standardized. Confidence intervals are at 10% level.

Figure B.7: Effects of domestic and international restrictions on the cancellation rate



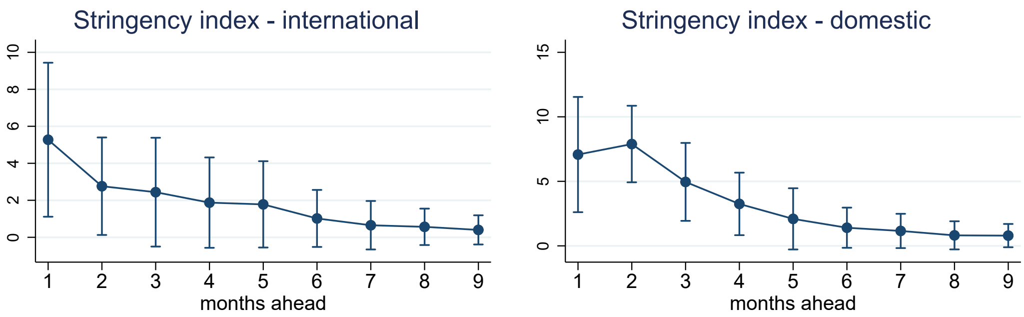
Note: The graph shows the coefficients of the regression of the cancellation rate on domestic and international restrictions for different time horizons. Regressors are standardized. Confidence intervals are at 10% level.

Figure B.8: Effects of domestic and international restrictions on the booking rate



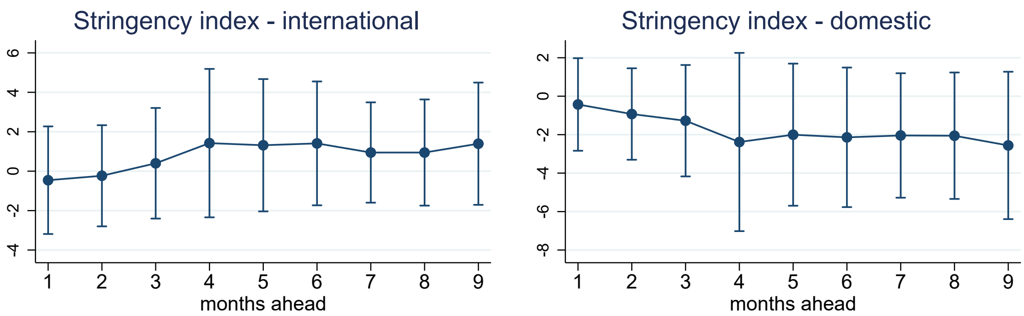
Note: The graph shows the coefficients of the regression of the booking rate on domestic and international restrictions for different time horizons. Regressors are standardized. Confidence intervals are at 10% level.

Figure B.9: Effects of domestic and international restrictions on the vacancy rate



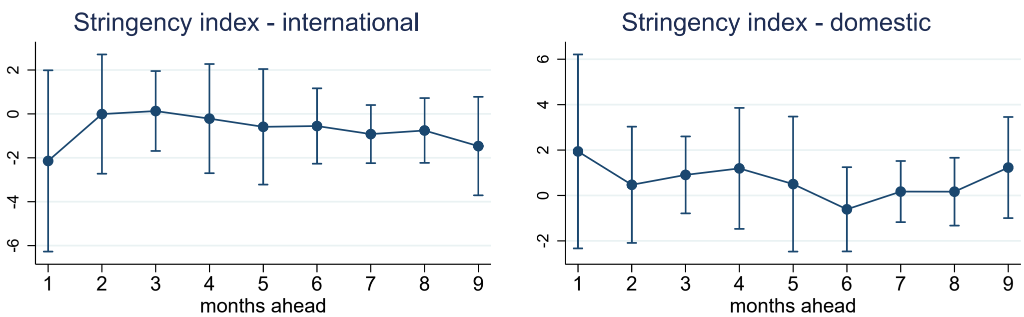
Note: The graph shows the coefficients of the regression of the vacancy rate on domestic and international restrictions for different time horizons. Regressors are standardized. Confidence intervals are at 10% level.

Figure B.10: Effects of domestic and international restrictions on the median price



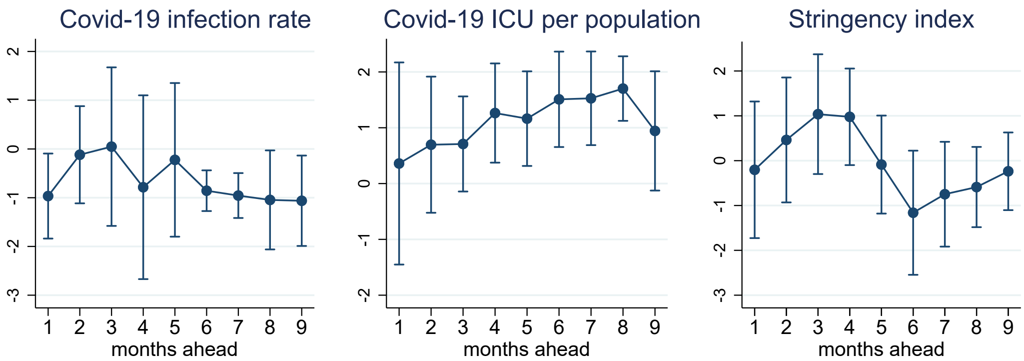
Note: The graph shows the coefficients of the regression of the median price on domestic and international restrictions for different time horizons. Regressors are standardized. Confidence intervals are at 10% level.

Figure B.11: Effects of domestic and international restrictions on the median hedonic price index



Note: The graph shows the coefficients of the regression of the median hedonic price index on domestic and international restrictions for different time horizons. Regressors are standardized. Confidence intervals are at 10% level.

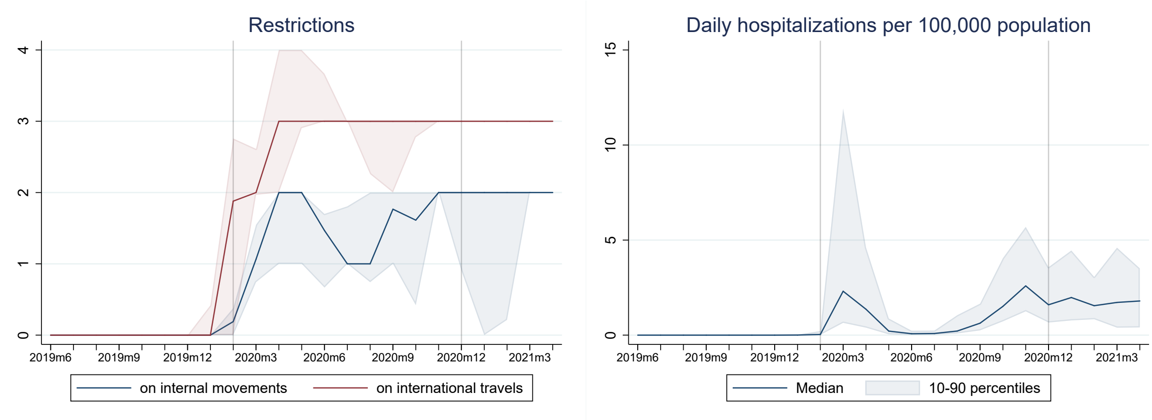
Figure B.12: Effects of linear projection on the median hedonic price index



Note: The graph shows the coefficients of the regression of the median hedonic price index on sanitary variables and the stringency index for different time horizons. Regressors are standardized. Confidence intervals are at 10% level.

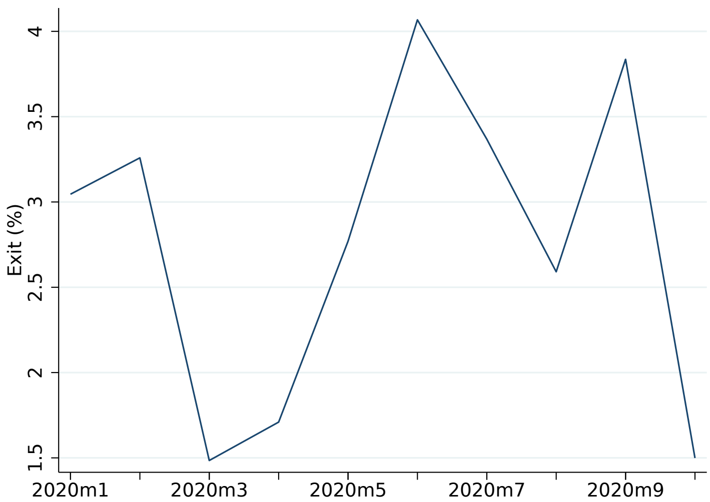
B.3 Quantitative evidence at the micro level

Figure B.13: Containment measures and hospitalizations in 21 French, Spanish and Italian markets



(a) *Domestic and international restrictions* (b) *Hospitalizations*

Figure B.14: Exit rate



Note: The graph shows the share of listings on the Airbnb website which exit the market in a given month.

Figure B.15: Cancellation rates (no control for selection)

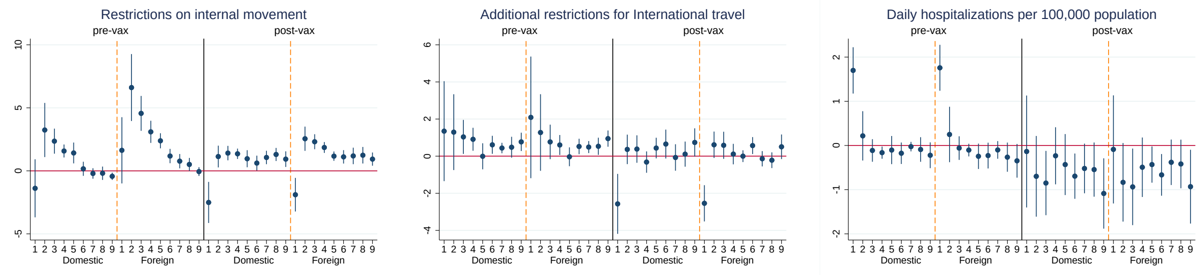


Figure B.16: Booking rates (no control for selection)

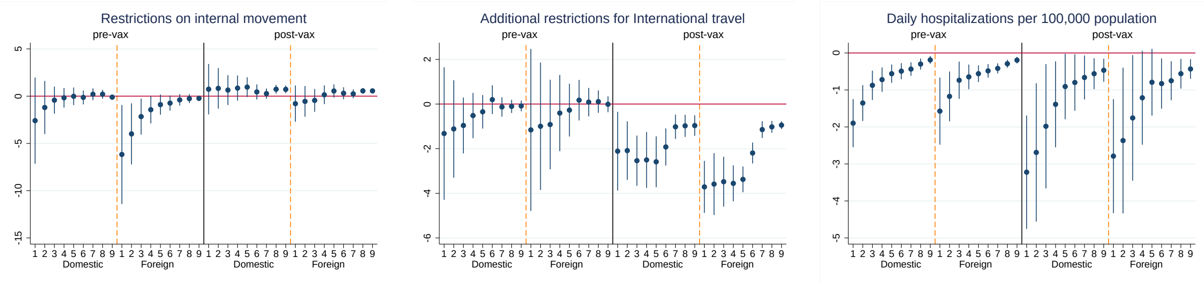


Figure B.17: Vacancies (no control for selection)

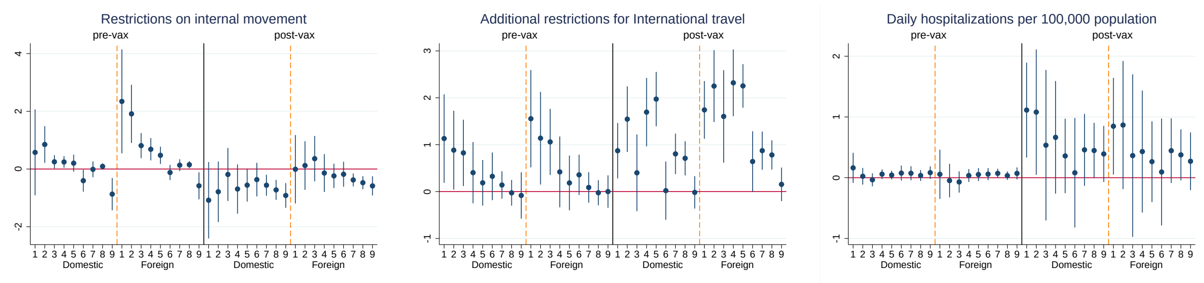
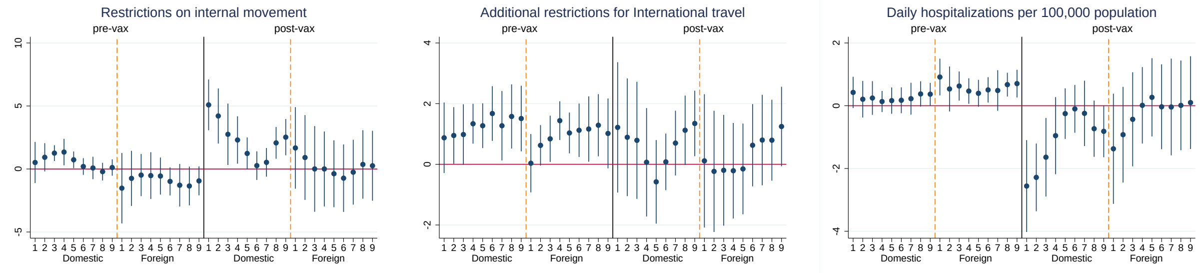


Figure B.18: Price variation (no control for selection)



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