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# Expanding the Doughnut? How the Geography of Housing Demand has changed since the rise of Remote Work with COVID-19

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The rise of remote working in connection with the COVID-19 pandemic may have reshaped people's preferences on residential locations, thus generating a new geography of housing demand. So far, the literature has mainly focused on what has become known as the "doughnut effect", the hollowing out of large metropolitan centres towards their respective suburban areas ("commuting zones"). However, changes in residential preferences might have affected urban and rural living in more nuanced ways. This paper shows that changes in relative house prices – a proxy for short-term changes in demand for home ownership ("housing demand") – have gone beyond the metropolitan boundaries, consistent with the idea of longer but less frequent home-to-work commuting. Interestingly, we are not seeing a re-emerging preference for rural life as such but, rather, a desire to move to places that combine the benefits of rural and urban life. In the areas outside the main metropolitan centres but within the commuting zones, housing demand has increased the most in low-density, more affordable, settlements (rural). In contrast, beyond the boundaries of large metropolitan areas, where most space tends to be rural, housing demand has increased the most in high-density settlements (cities).

**JEL codes:** R21, J61, R12, O18.
**Keywords:** Housing demand, remote working, degree of urbanisation, COVID-19.

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# 1 Introduction

The COVID-19 pandemic led to a dramatic increase in remote working, in particular during periods of lockdown. Indeed, after more than three years, remote working remains widely used, and is expected to continue to do so (Bloom, Han and Liang, 2023[1]; Barrero, Bloom and Davis, 2021[2]). This shift has potential implications for the spatial organisation of several human activities. Remote working reduces the number of days workers need to commute, allowing people to be less constrained in their choices of where to live, including to live farther away from workplaces located in high-density areas. According to recent studies, new working and commuting arrangements will result in long-term changes in the geography of housing demand (Brueckner, Kahn and Lin, 2023[3]).

An emerging literature suggests that since the start of COVID-19, many large metropolitan areas in developed countries have experienced higher housing demand in their suburbs than in their city centres, also known as the “doughnut effect” (Ramani and Bloom, 2021[4]). This has led to an average flattening of the house price-to-distance gradient – the negative relationship between house prices and distance to the city centre – within many large metropolitan areas (Gupta et al., 2021[5]; Ahrend et al., 2022[6]; Ziemann et al., 2023[7]). These studies provide a first picture of how residential preferences are re-organising between more central and peripheral locations within metropolitan areas, which in most cases already cover quite large areas. But little is known on whether housing demand is increasing even beyond these large metropolitan boundaries (i.e., areas which tend to be relatively far away from the metropolitan centre). In addition to a shift in housing preferences within the metropolitan space, the potential expansion of functional metropolitan boundaries has important implications for urban policies, notably related to housing and transport, and more generally to sustainable urban development (for a detailed discussion on related policy implications see (OECD, 2023[8]; OECD, 2023[9])).

This study fills this void in the literature by showing that changes in home ownership demand (hereafter “housing demand”) – proxied through changes in house prices[1] – has been expanding even beyond the boundaries of large metropolitan areas since the COVID-19 outbreak and the related increase of teleworking. It also provides evidence on the specific location characteristics associated with the observed changes in housing preferences.

The analysis builds on quarterly data (from 2018 Q1 to 2021 Q4) on dwelling purchases (including houses and apartments) and related prices (hereafter referred to as “house prices”) for small geographical units located in large metropolitan areas (i.e., functional urban areas, FUAs, of at least 1.5 million inhabitants or the largest FUA in the country) and their surroundings in 16 OECD countries. Metropolitan areas are delineated consistently using the OECD-EU definition of functional urban areas (Dijkstra, Poelman and Veneri, 2019[10]), which consist of a densely populated area (“core”) and its commuting zone. This allows capturing the relevant extent of local labour markets that were in place before the pandemic (metropolitan areas), as well as their potential area of expansion due to COVID-19 and remote working (“extended” metropolitan areas).

Through different empirical specifications at the small area unit level, while controlling for extended metropolitan areas fixed effects, the paper disentangles changes in house prices before and during COVID-19 across the different rings surrounding metropolitan centres. The paper also looks at the trends

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[1] Under the assumption that housing supply is relatively inelastic within short periods of time.

in house prices by type of settlement within specific spatial rings. The use of the degree of urbanisation, DEGURBA (OECD et al., 2021[11]) (based on population estimates at the grid level for 2015[2]), to classify the types of settlements in different spatial rings within and beyond the metropolitan space maximises international comparability and allows a nuanced analysis of the changing housing preferences along the urban-rural continuum.

Results show that once most COVID-19 related lockdowns ended, and people were able to move again, house prices started increasing faster outside metropolitan centres, even beyond their (already large) commuting zones, reaching more distant areas – outside the metropolitan boundaries – referred to as “the buffers”. Within commuting zones, rural areas – also characterised by relatively cheaper house prices – have gained attractiveness in terms of higher home ownership demand (reversing pre-pandemic trends), while within the closest buffers around metropolitan boundaries, (smaller) cities have seen a higher house price increase during the pandemic years (2020-2021) – in contrast with the pre-pandemic period (2018-2019).

In the “new normal” characterised by higher adoption of remote working and less frequent commuting, the evidence provided by this study suggests an increasing tendency for people to live (or spend more time) farther away from the most central and dense locations. However, new housing preferences seem to value either close access to a metropolitan centre (the case of more affordable rural areas in commuting zones) or, for the case of locations outside metropolitan boundaries, a minimum density level provided by other (smaller) cities. This indicates that we are not seeing a re-emerging preference for rural life as such, but rather an increased preference for places that combine the benefits of both rural and urban life.

The remainder of the paper is organised as follows: Section 2 presents the data and definitions, while Section 3 provides a statistical overview of recent trends in the geography of housing demand. Section 4 presents the empirical specifications and the results. Finally, Section 5 provides some conclusions and venues for future work.

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[2] Population estimates at the 1 km$^2$ grid level for 2015 come from the Global Human Settlement Layer (GHSL) Data package of 2019 (Florczyk, 2019[13]), which was the latest version available at the time of writing.

# 2 Data and definitions

### *Housing data*

The Geography of Housing Demand (GHD) database, built by the OECD in collaboration with public and private data providers (see Table 2.1), gathers the total number of dwelling purchases and average prices for 16 OECD countries at the small area unit (SAU) level. It is worth highlighting that the GHD indicators do not cover rents. Thus, the analysis focuses on home ownership demand, which, for simplicity, is also referred to as "housing demand" throughout the paper. Studying dwelling purchases (which tend to be forward looking) rather than rents (which tend to reflect current developments) (Gupta et al., 2021[5]; Van Nieuwerburgh, 2022[12]), might allow capturing more persistent shifts in housing preferences.

Table 2.1. Data sources and coverage

| Country | Geographical units | Time coverage | House price indicator | Source |
|---|---|---|---|---|
| Austria | 1 075 municipalities | 2015Q1 - 2022Q1 | Median price per $m^2$ | Statistik Austria |
| Belgium | 589 municipalities | 2010Q1 - 2021Q4 | Mean price per $m^2$ | STATBEL |
| Germany | 4 413 postal codes and 80 districts | 2018Q1 - 2021Q4 | Mean price per $m^2$ | vdpResearch |
| Denmark | 605 postal codes | 1992Q1 - 2022Q1 | Mean price per $m^2$ | Statistics Denmark |
| Spain | 5 369 municipalities and 31 districts | 2007Q1 - 2021Q3 | Mean price per $m^2$ | INE |
| Finland | 225 municipalities | 2010Q1 - 2021Q4 | Mean price per $m^2$ | Statistics Finland |
| France | 33 304 communes | 2014Q1 - 2021Q4 | Mean price per $m^2$ | Demande de valeurs foncières (DVF) |
| United Kingdom | 8 393 postcode sectors | 1995Q1 - 2022Q3 | Mean price adjusted by dwelling characteristics | UK Government Price Paid data |
| Norway | 56 municipalities | 2006Q1 - 2021Q4 | Mean price per $m^2$ | Statistics Norway |
| Portugal | 2 110 parishes | 2009Q1 - 2021Q4 | Mean price per $m^2$ | Confidencial Imobiliário |
| United States | 27 403 zip codes | 1996Q1 - 2022Q3 | Mean price adjusted by dwelling characteristics | Zillow Research Institute |
| Israel | 798 cities | 2006Q1 - 2021Q4 | Mean price per $m^2$ | Central Bureau of Statistics |
| Korea | 250 municipalities | 2018Q1 - 2021Q4 | Mean price per $m^2$ | MOLIT |
| Hungary | 2 914 settlements and 23 districts | 2008Q1 - 2022Q1 | Mean price per $m^2$ | Hungarian Central Statistics Office |
| Sweden | 275 municipalities | 2015Q1 - 2021Q4 | Mean price per $m^2$ | Svensk Mäklarstatistik |
| Mexico | 10 705 zip codes | 2016Q1 - 2021Q4 | Mean price per $m^2$ | Sociedad Hipotecária Federal (SHF) |

For all the countries in the sample, the database covers the first half of 2018 to the second half of 2021, allowing for a look at trends in the geography of home ownership demand before and during the pandemic. Average dwelling prices are expressed as per square-metre, except for two countries (the UK and the US), where prices are adjusted for other observable characteristics. The UK data is adjusted by house types (detached houses, semi-detached houses, terraced houses, and flats or maisonettes), and the US data is seasonally adjusted and considers number of rooms (Ahrend et al., 2022[6]).

As quarterly housing transactions and prices in small area units can be highly volatile, the analysis is based on either semestrial or yearly aggregates. In addition, when the number of transaction is too small, price distributions and time series can be extremely noisy. For this reason, SAUs with less than ten transactions per year are dropped from the sample[3] (for more technical details on data treatment see Annex D).

### *Geographical units*

House prices are measured at the scale of SAUs (small area units). Depending on the country, these units correspond, for example, to zip codes, districts, or municipalities (Table 2.1). SAUs can be mapped to metropolitan areas and their surroundings (buffers), allowing for highly granular analysis within and in the neighbourhood of large urban centres.

Metropolitan areas are defined using the concept of Functional Urban Area (FUA) developed jointly by the OECD and the European Commission (Dijkstra, Poelman and Veneri, 2019[10]). A FUA consists of a densely populated area (also referred to as the "core") and a commuting zone whose labour market is highly integrated with the core through at least 15% of the working force commuting to the core. FUAs are delineated consistently across countries to maximise international comparability. This paper focuses on large metropolitan areas – i.e., FUAs of more than 1.5 million inhabitants or the largest FUA in the country for the cases of Norway and Finland – and their surroundings, expanding the scope of the analysis compared to the recent literature (Ramani and Bloom, 2021[4]; Gupta et al., 2021[5]; Ahrend et al., 2022[6]) that documents spatial changes in housing demand only within the boundaries of large metropolitan areas.

Only small area units belonging to a large metropolitan area or its buffers are considered for the analysis – which yields a sample of almost 45 000 SAUs distributed across 80 metropolitan areas and their buffers. Table 2.2 shows the list of large metropolitan areas covered in this paper, as well as the number of local units, their average population and area. Out of these 80 metropolitan areas, 36 are in the US and 29 in Europe. The granularity of SAUs can differ widely across countries. For example, SAUs in France are much more granular than those in Korea. The average population in French SAUs amounts to around 6 000 people, whereas in Korea it is more than 50 times higher and close to 342 000 people. In terms of density, Korean SAUs are eight times more dense than French SAUs, on average.

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[3] Excluding SAUs with less than ten transactions could introduce biases in the analysis (e.g. underestimating home ownership demand in less dynamic, low-density, places). However, the cost of keeping them would be a source of unrealistic values for some SAUs, as well as higher standard errors undermining normality and statistical inference.

## Table 2.2. Metropolitan areas covered in the analysis

| Country | Metropolitan areas | Number of metropolitan areas | Number of SAUs | Average SAU population | Average SAU area (km$^2$) | Average SAU density (people per km$^2$) |
|---|---|---|---|---|---|---|
| Austria | Vienna | 1 | 643 | 9 350 | 33.1 | 918 |
| Belgium | Brussels/Leuven | 1 | 424 | 34 409 | 43.8 | 2 106 |
| Germany | Berlin, Hamburg, Munich, Köln, Frankfurt am Main, Ruhrgebiet, Stuttgart, Düsseldorf | 8 | 2 861 | 25 297 | 37.4 | 4 009 |
| Denmark | Copenhagen | 1 | 172 | 23 110 | 41.6 | 2 467 |
| Spain | Madrid, Barcelona, Valencia | 3 | 1 156 | 12 772 | 40.2 | 2 033 |
| Finland | Helsinki | 1 | 55 | 40 278 | 313.4 | 305 |
| France | Paris, Lyon, Marseille, Lille, Toulouse | 5 | 9 554 | 6 156 | 12.7 | 1 024 |
| United Kingdom | London, West Midlands urban area, Leeds, Liverpool, Manchester | 5 | 5 639 | 23 612 | 13.1 | 32 620 |
| Norway | Oslo | 1 | 73 | 27 248 | 467.7 | 135 |
| Portugal | Lisbon | 1 | 283 | 23 776 | 45.2 | 3 643 |
| United States | New York (Greater), Los Angeles (Greater), Chicago, Washington (Greater), San Francisco (Greater), Philadelphia (Greater), Dallas, Houston, Miami (Greater), Atlanta, Phoenix, Detroit (Greater), Seattle, Minneapolis, St. Louis, Denver, Portland, Cincinnati, Orange, Jackson (MO), Cuyahoga, New Haven, Charlotte, Sacramento, Jacksonville, Salt Lake, Tampa-Pinellas, Boston, San Diego, San Antonio, Las Vegas, Indianapolis, Austin, Columbus, Milwaukee, Tampa-Hillsborough | 36 | 13 469 | 26 660 | 138.5 | 6 755 |
| Israel | Tel Aviv - Yafo | 1 | 425 | 26 389 | 8.1 | 10 219 |
| Korea | Gimhae, Dalseong, Gwangsan, Seoul, Seo | 5 | 186 | 341 563 | 308.4 | 8 379 |
| Hungary | Budapest | 1 | 804 | 8 388 | 32.1 | 542 |
| Sweden | Stockholm | 1 | 60 | 79 348 | 480.5 | 799 |
| Mexico | Mexico City, Guadalajara, Monterrey, Puebla, Toluca, Tijuana, Leon, Queretaro, Torreon | 9 | 9 102 | 24 632 | 17.6 | 55 374 |
| **Total** | | **80** | **44 906** | **45 812** | **127.1** | **8 208** |

***Defining spatial buffers***

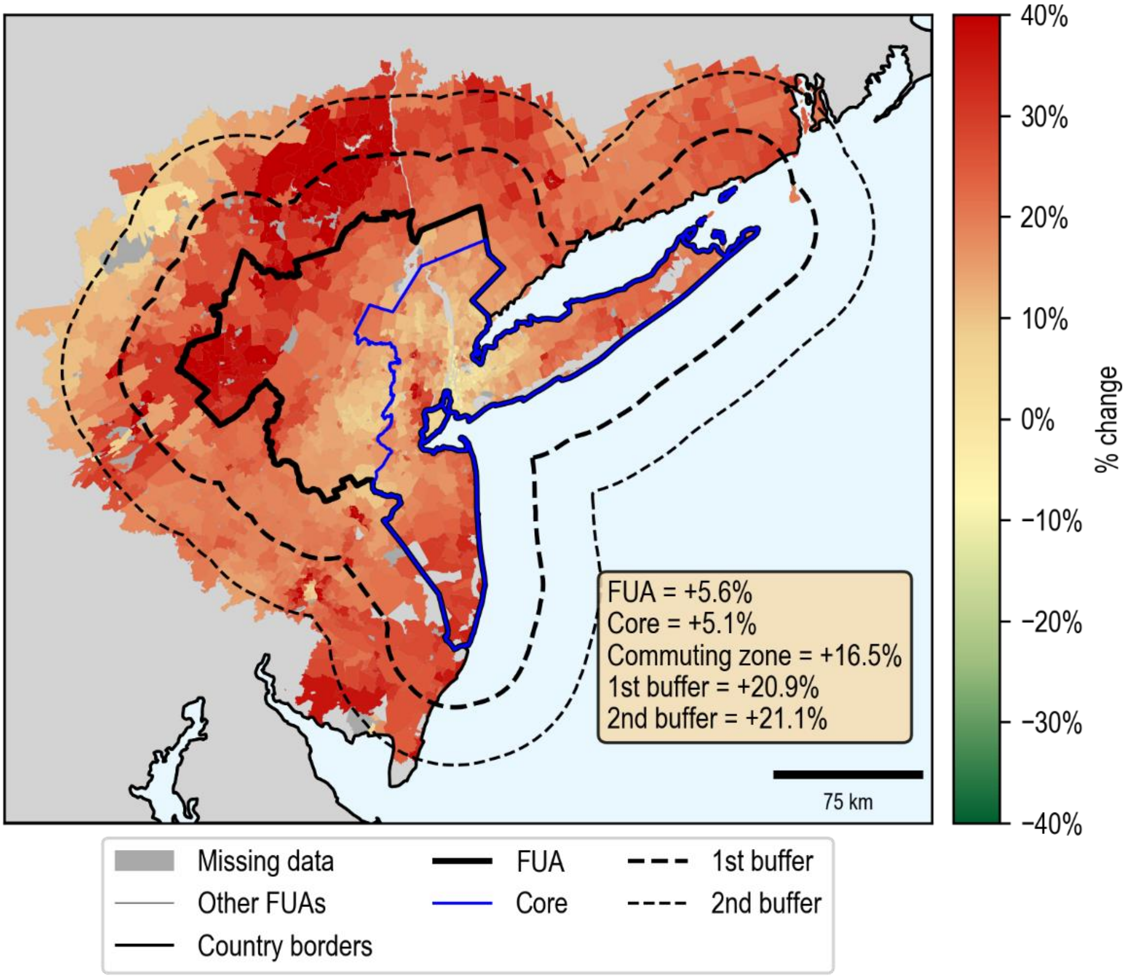
To look at the evolution of house prices beyond the boundaries of metropolitan areas, two concentric buffers were delineated for each FUA with more than 1.5 million inhabitants (or the largest FUA for Norway and Finland). The buffers, which refer to areas around the FUA edges, were demarcarted by a distance (from the edge of the FUA) defined as a proportion of the square root of the FUA area, as follows:

$$Buffer1 = 0.2 * \sqrt{area_{FUA}} \text{ and } Buffer2 = 0.4 * \sqrt{area_{FUA}}$$

These definitions allow for the delineation of buffers that take into account the heterogeneity in area size across OECD metropolitan areas. Commuting zones and buffers are also referred to as “rings”, and metropolitan areas together with their buffers as “extended metropolitan areas”. As an example, Figure 2.1 shows house price changes in the different spatial rings of the extended metropolitan area of New York (see Annex A for a larger selection of extended metropolitan areas).

Figure 2.1. Evolution of house prices in New York’s metropolitan area and their surroundings

House price change (%), from 2019 to 2021

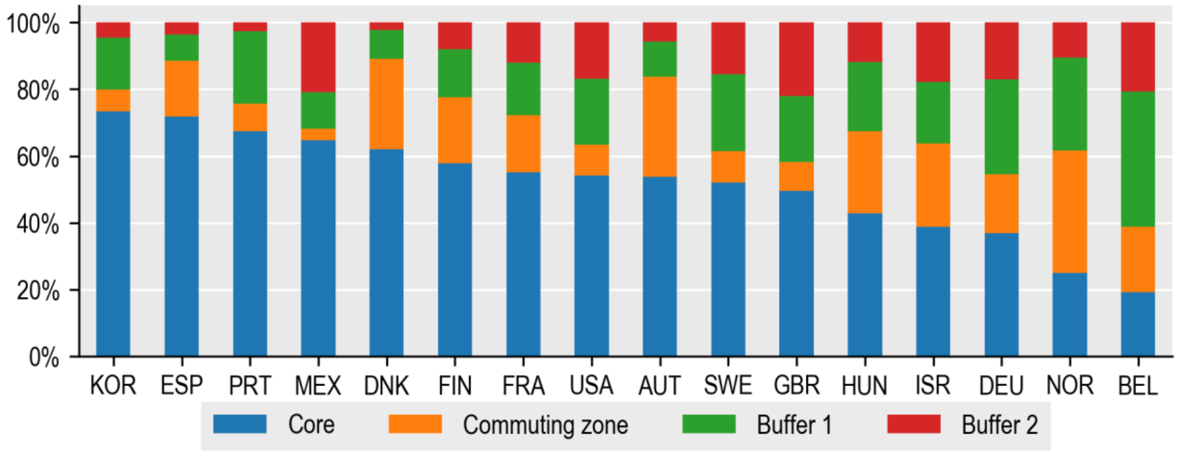


Note: House price change is the percentage change in yearly average house prices. The yearly average house price is obtained at the SAU level by taking the simple average across quarters. Price aggregates for the metropolitan areas (FUA), the cores and the different rings are obtained by taking the population-weighted average house price across SAUs.

The distribution of population across rings within extended metropolitan areas can differ widely across countries due to differences in settlement patterns at the edge and outside of large metropolitan areas. Figure 2.2 shows the distribution of population across metropolitan cores and their respective rings in each country. In Korea and Spain, for example, most of the population is concentrated in the cores, whereas in Belgium, Germany and Norway, the population is more evenly distributed between the zones of the extended metropolitan area (for the distribution of SAUs across the core and the rings by country, see Figure B.1 in the annex).

Figure 2.2. Population distribution by zone, 2020

Share of population across extended large metropolitan areas (core, commuting zone, and buffers)



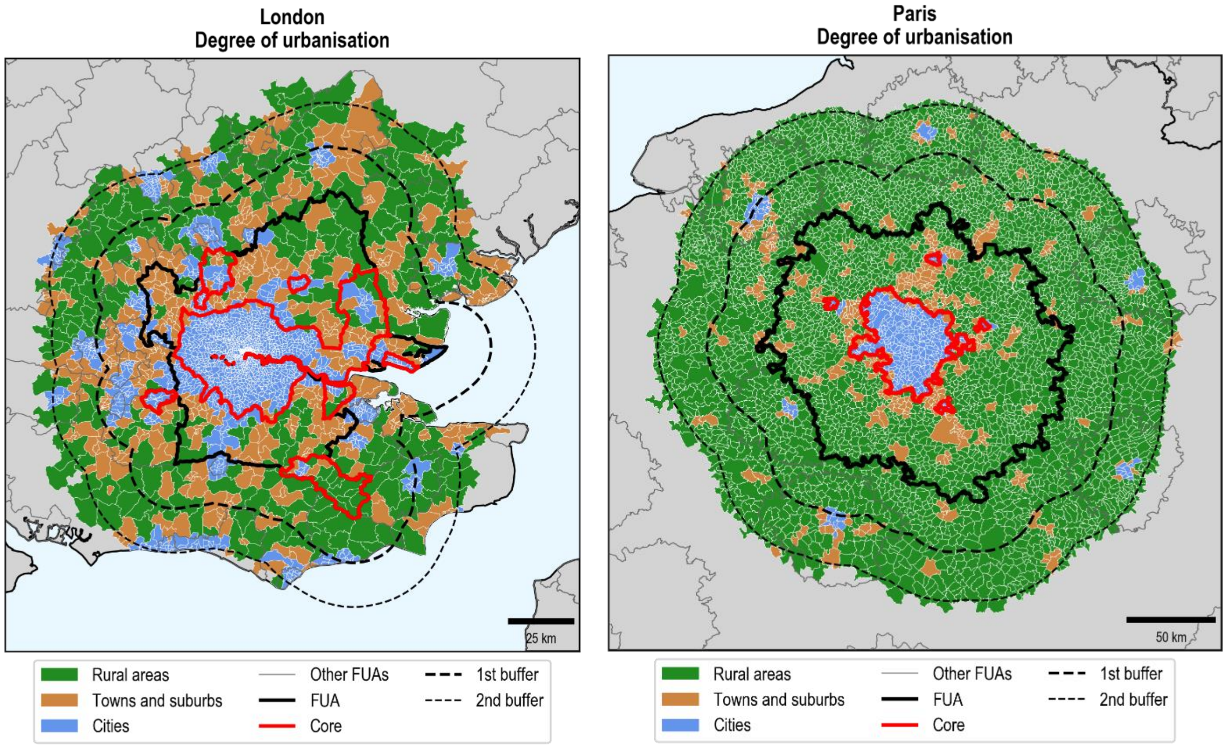
Note: Only geographical units located within large metropolitan areas and their buffers are included.

### The degree of urbanisation

To characterise the places experiencing changes in home ownership demand, SAUs are classified by their degree of urbanisation (DEGURBA) (OECD et al., 2021[11]) into either rural areas, towns and suburbs (hereafter referred to as towns for simplicity), or cities (the empirical analysis by DEGURBA looks only at cities outside the centres of large metropolitan areas). The classification of SAUs by DEGURBA is based on 2015 population estimates at the 1 km$^2$ level (latest year available at the time of writing) from the Global Human Settlement Layer (GHSL) Data Package of 2019 (Florczyk, 2019[13]). The degree of urbanisation is a global methodology endorsed by the United Nations (UN) enabling the delineation of cities, urban and rural areas in an internationally comparable way. While the FUA methodology allows the mapping of SAUs to the metropolitan area they belong to, based on their economic, commuting and labour market integration, the DEGURBA methodology allows to classify each individual SAU by their degree of "urbanity", based on consistent thresholds of population size and density.

The spatial distribution of SAUs by degree of urbanisation is heterogeneous between and within the metropolitan areas and their surroundings. Figure 2.3 displays small units by degree of urbanisation in the extended metropolitan areas of London (UK) and Paris (France). The maps show that the distribution of SAUs is uneven across spatial rings and by degree of urbanisation even within the same extended metropolitan area. For example, in both London and Paris, SAUs are very granular in urban centres. However, relative to SAUs in the metropolitan core, SAUs outside the metropolitan core are larger in London than Paris. In addition, the distribution of SAUs in London's buffers is more balanced between rural areas, towns, and cities, while in Paris's buffers most SAUs are rural.

Figure 2.3. Extended metropolitan areas of London and Paris by degree of urbanisation

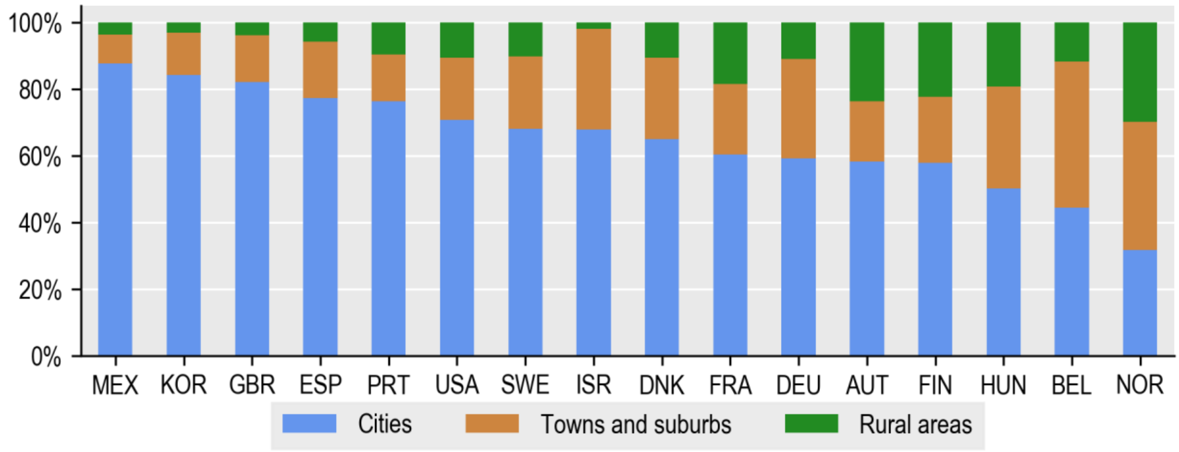


Yet, in most OECD countries with available data, the population of extended metropolitan areas is concentrated in cities rather than in towns or rural areas. Figure 2.4 and Figure 2.5 show the distribution of population across the different degrees of urbanisation and the rings in each country. In 14 out of 16 countries, most of the population located within extended metropolitan areas lives in cities. Only in Belgium and Norway, is the share of population larger outside cities (i.e., in towns and rural areas).

Within commuting zones, most of the population lives in towns, except in the UK, where the population share is higher in cities. In the buffers, the population distribution varies a lot across countries. On the one hand, in countries such as Austria, Denmark and Finland, most people in the buffers live in towns and rural areas. On the other hand, in countries such as Germany, Mexico, the UK and the US, most of the population in the buffers remains concentrated in cities (Figure B.2 and Figure B.3 in the annex also show the distribution of SAUs across the types of settlement and the rings by country).

## Figure 2.4. Population distribution by degree of urbanisation, 2020

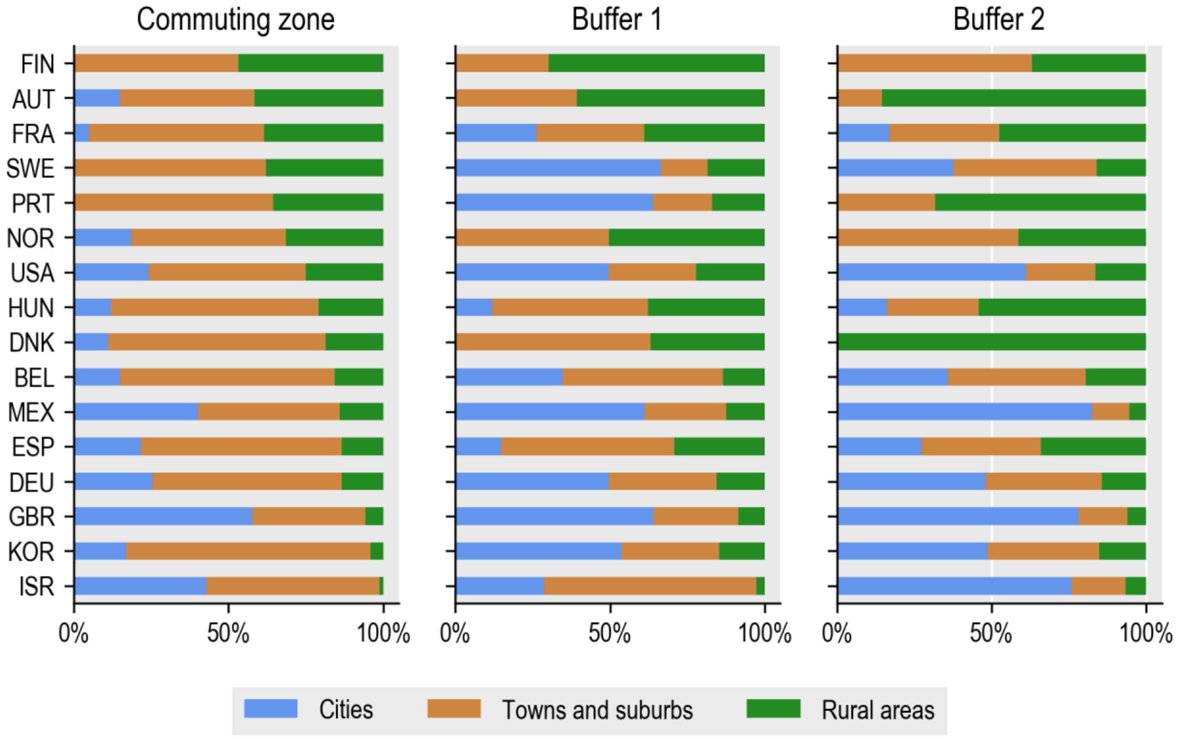
Share of population across degrees of urbanisation in large metropolitan areas plus their buffers



Note: Only geographical units located within large metropolitan areas and their buffers are included.

## Figure 2.5. Population distribution by metropolitan ring and degree of urbanisation, 2020

Share of population across degrees of urbanisation for different zones in extended metropolitan areas



Note: Only geographical units located within large metropolitan areas and their buffers are included.

# 3 Spatial changes in housing demand

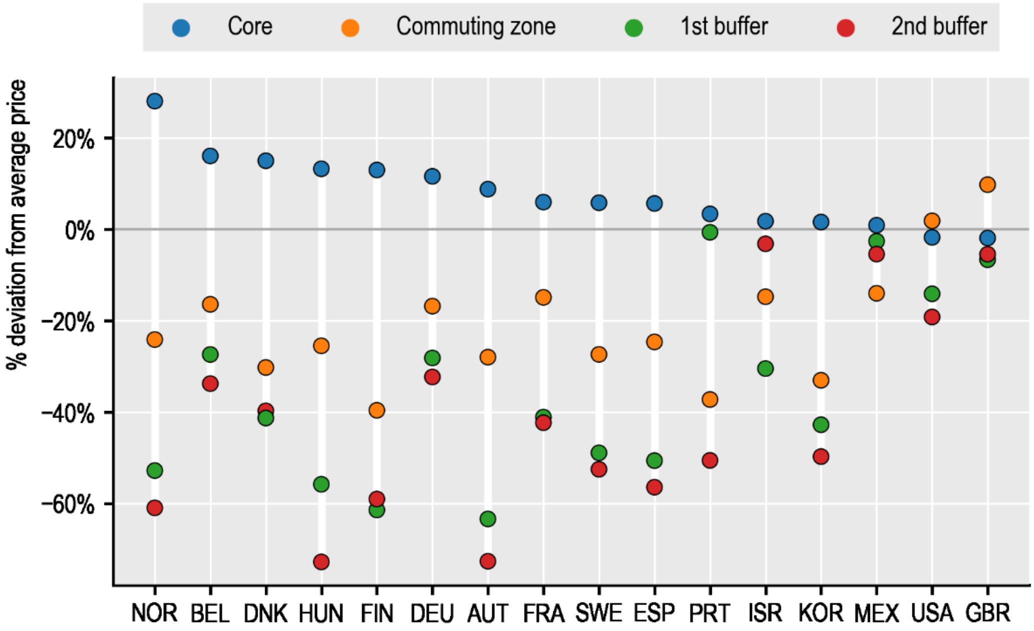
### *Stylised facts on the geography of housing demand*

Traditional urban economics theory predicts that land prices peak in central business districts – typically located within the metropolitan core – and decrease with distance from them (Alonso, 1964[14]). Indeed, house prices tend to be highest in dense city centres, mainly due to relative land scarcity, lower home-to-work commuting costs and higher access to urban amenities (Duranton and Puga, 2020[15]). In OECD countries with available data, average house prices in the metropolitan core are close to 8% higher than average house prices in the whole metropolitan area (i.e., core and commuting zone, Figure 3.1).

The house price gap between metropolitan centres and outer rings holds in most OECD countries, with few exceptions. In 14 out of 16 countries, price levels in the cores are higher than in the commuting zones and the buffers. Only in the UK and the US, are house prices slightly higher (or at least similar) in the commuting zones than in the cores. In the UK, this might come from a limitation of its data, which doesn't control for house size, while in the US, this might be related to a long-term trend of growing preferences for suburban life since the second half of the 20th century (Kruse and Sugrue, 2006[16]) (Figure 3.1).

Figure 3.1. House price disparities across the zones of the extended metropolitan areas

Average percentage deviation (%) from the average house price in the metropolitan area, 2021



Note: Only geographical units located within large metropolitan areas and their buffers are included. Yearly average house prices at the SAU level are obtained by taking the simple average across quarters. Price aggregates for the metropolitan areas (FUA), the cores and the different rings are obtained by taking the population-weighted average house price across SAUs.

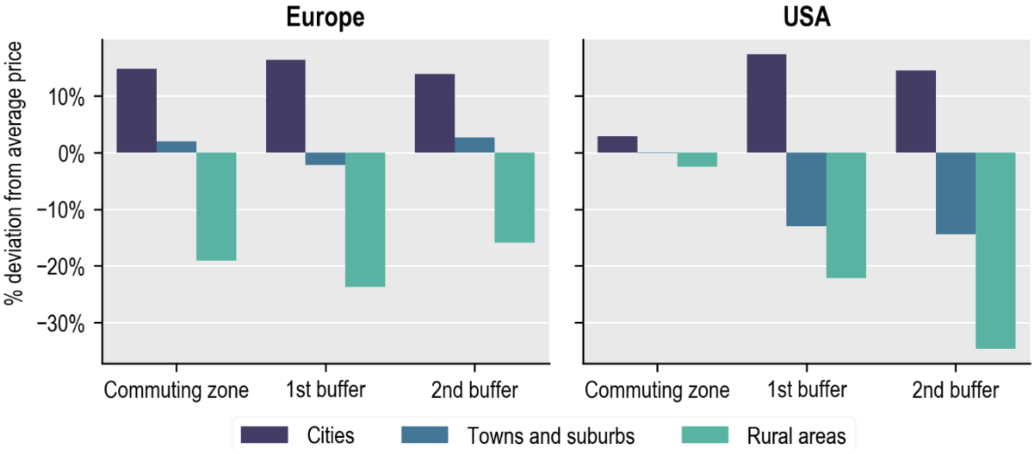
The data collected for this study reveal that house prices tend to decrease markedly as one moves from the metropolitan cores to the outer rings. The average difference in relative house prices (percentage deviations from the metropolitan area average) between the core (typically the highest price deviation) and the commuting zone is of around 30 percentage points (pp), while the differences between the core and the first and second buffers (typically the lowest price deviations) are close to 40 and 50 pp, respectively. The price-to-ring distance relationship – which captures and expands the price-to-distance gradient within metropolitan areas – also holds for most extended metropolitan areas in the sample. Indeed, in 69 out of 80 extended metropolitan areas, prices are higher in the core and decrease until the second buffer (see Table B.1-Table B.4).

Price differentials across concentric rings might reflect high commuting and transport costs in outer areas (Duranton and Puga, 2019[17]), as well as preferences and cultural factors, which can vary across countries. For example, discrepancies in price levels between metropolitan cores and buffers (e.g., rings outside commuting zones) are particularly large in Austria, Hungary and Norway – above 80 pp. In countries such as the UK and the US, the price disparity is much lower – below 20 pp – which could be partly explained, if not by lower transport costs, by a more prevalent culture of long commutes and car-dependency (OECD, 2022[18]) (Figure 3.1).

House prices also change significantly by degree of urbanisation *within* a given metropolitan ring, revealing substantial differences across settlement density. In both Europe and the US, house prices in cities tend to be much higher than in towns and rural areas, on average. In Europe, in all rings, house prices in cities are on average between 14% and 16% higher than the average house price, whereas in rural areas, prices are between 16% and 24% lower. This pattern is stable across rings. In the US, the dispersion of prices across settlement types tends to increase with a ring's distance to the core. While prices by degree of urbanisation are relatively similar in the commuting zone, those in the second buffer are very uneven – where prices in rural areas are 35% below the average and those in cities are 17% above the average (Figure 3.2). Wider dispersion in house prices in the US buffers, relative to Europe, could reflect higher income segregation (OECD, 2018[19]), as well as important disparities in access to public services and amenities across settlement types.

## Figure 3.2. House price disparities across degrees of urbanisation and rings

Percentage deviation (%) from the average house price in each ring, 2021



Note: The panel for Europe only covers the European countries in the database, excluding the UK. Only geographical units located within large metropolitan areas and their buffers are included. Yearly average house prices at the SAU level are obtained by taking the simple average across quarters. Price aggregates for the metropolitan areas and the different rings are obtained by taking the population-weighted average house price across SAUs.

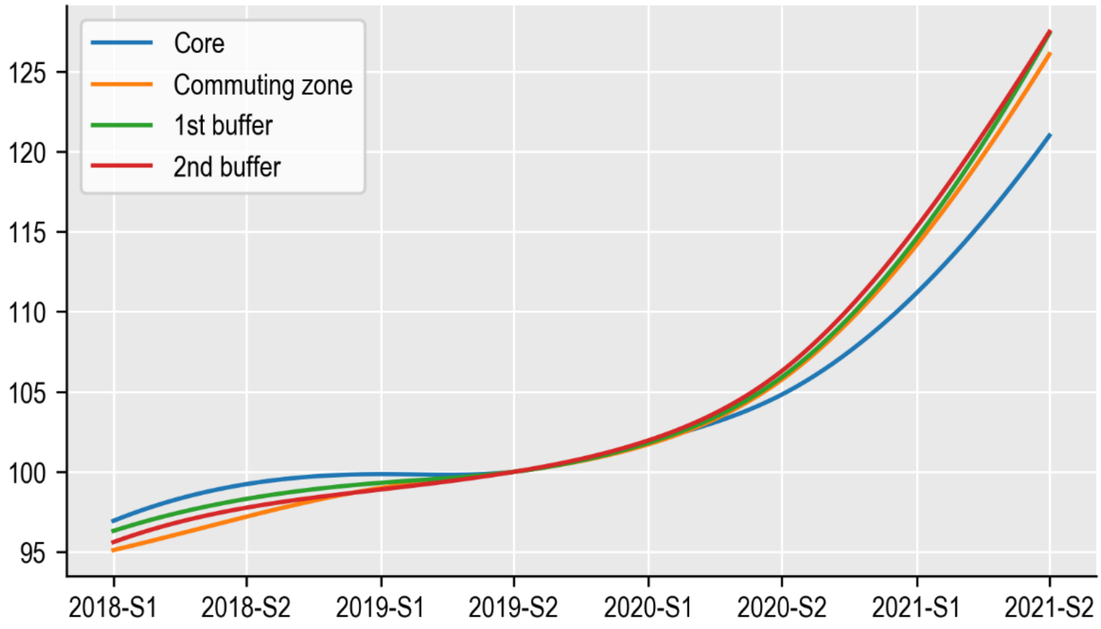
### *New trends in the geography of housing demand*

In the 20 years before the COVID-19 pandemic, house prices increased dramatically in most OECD countries, especially in large cities (OECD, 2021[20]) and even more so in the central areas of those large cities (Glaeser, Gottlieb and Tobio, 2012[21]). Yet, trends such as the "housing booms of city centres" – which to a large extent were the result of prolonged periods of low interest rates, high attractiveness of central locations, and inelastic housing supply (Gyourko, Mayer and Sinai, 2013[22]) – occurred in a context of very limited adoption of remote working compared to more recent times. Indeed, the prevalence of working from the office heightened workers' willingness to pay for central locations to reduce commuting costs and times.

With COVID-19 and the rise of remote work practices (even if only for a few days during the week), the need for commuting has declined as also indicated by falling commuting hours (Barrero, Bloom and Davis, 2021[2]; Bloom, 2020[23]), allowing some workers to live in less central and dense locations. Recent OECD work documented that since 2020, house prices within large metropolitan areas have been growing faster in the commuting zones (12%) relative to the central neighbourhoods (7%) (OECD, 2022[18]). This paper completes the picture by showing that housing demand increases were not limited to commuting zones, but also reached areas beyond the metropolitan boundaries.

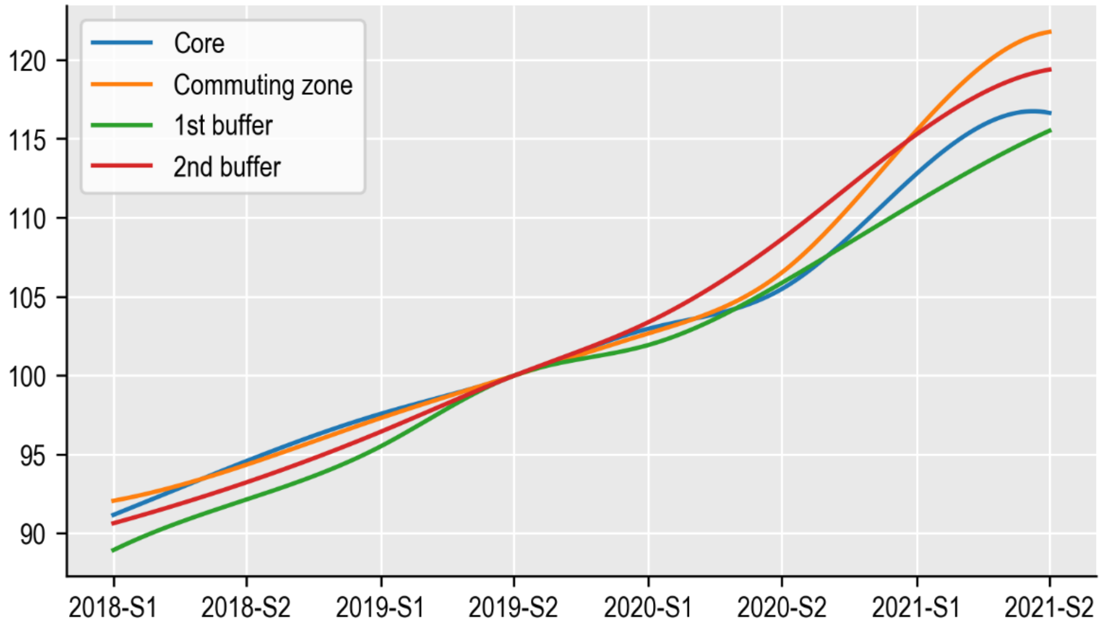
In 2021, when most lockdowns ended and partial working from home (i.e., people working some days at home and some days at the office) became "the new normal" (Bloom, Han and Liang, 2023[1]; Aksoy et al., 2023[24]), housing demand in large metropolitan areas started increasing faster in the commuting zones and surroundings (buffers) relative to the city centres, on average. Figure 3.3 and Figure 3.4 show the evolution of house prices in extended large metropolitan areas in the US and Europe since the first semester of 2018 (2018-S1). In the US, house prices increased much faster during the pandemic than before, and at a higher rate in the commuting zones and the buffers than in the cores. Between 2019-S2 and 2021-S2, house prices increased by 21% in the cores of US large metropolitan areas, by 26% in the commuting zones and by 27% in the buffers. EU large metropolitan areas show a similar, albeit less clear, pattern. From 2019-S2 to 2021-S2, house prices in the EU increased by 17% in the cores, by 22% in the commuting zones and by around 19% in the second buffers. This suggests that in Europe the commuting zones experienced the highest gains in attractiveness, whereas in the United States the highest gains were in the buffers.

Figure 3.3. Average house prices in US extended metropolitan areas (2019-S2 = 100).



Note: Only geographical units located within large metropolitan areas and their buffers are included. Average house prices at the semester level are obtained by taking the simple average across quarters. Price aggregates for the different rings are obtained by taking the population-weighted average house price across SAUs.

Figure 3.4. Average house prices in European extended metropolitan areas (2019-S2 = 100)

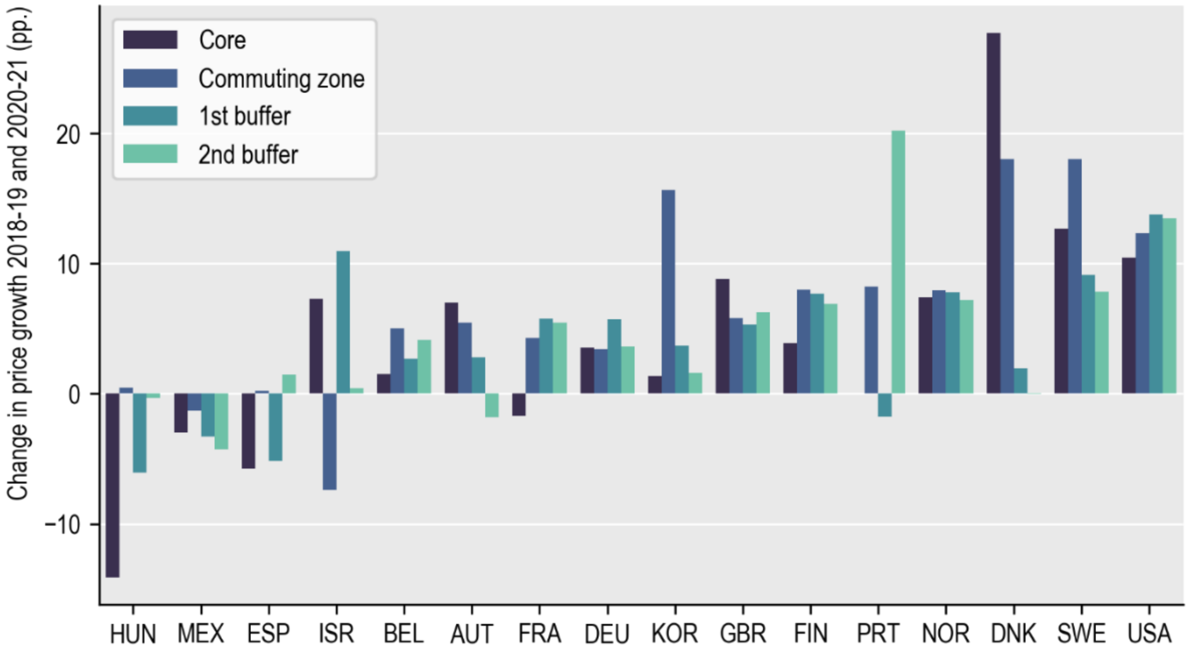


Note: Average house prices refer to price per $m^2$. This chart only covers the European countries in the database excluding the UK. Only geographical units located within large metropolitan areas and their buffers are included. Average house prices at the semester level are obtained by taking the simple average across quarters. Price aggregates for the different rings are obtained by taking the population-weighted average house price across SAUs.

The acceleration of house price growth since the beginning of the pandemic is observed in most countries and zones within extended metropolitan areas and was higher outside the metropolitan cores. As higher price growth outside the metropolitan centres could be part of a longer pre-COVID trend, Figure 3.5 shows the difference between COVID and pre-COVID house price growth rates (i.e., the simple difference in year-on-year price growth rates between 2018-19 and 2020-21). In 13 out of 16 countries, price growth sped up in most of the extended metropolitan space – i.e., including both the cores and the rings – since the beginning of the pandemic. The figure also shows that in 10 of those 13 countries, price growth rates in the commuting zones and outer rings increased faster compared to the cores.

### Figure 3.5. Difference in house price growth rates between 2018-19 and 2020-21 by country and by ring

Price growth rate from 2020 to 2021 minus Price growth rate from 2018 to 2019, in percentage points

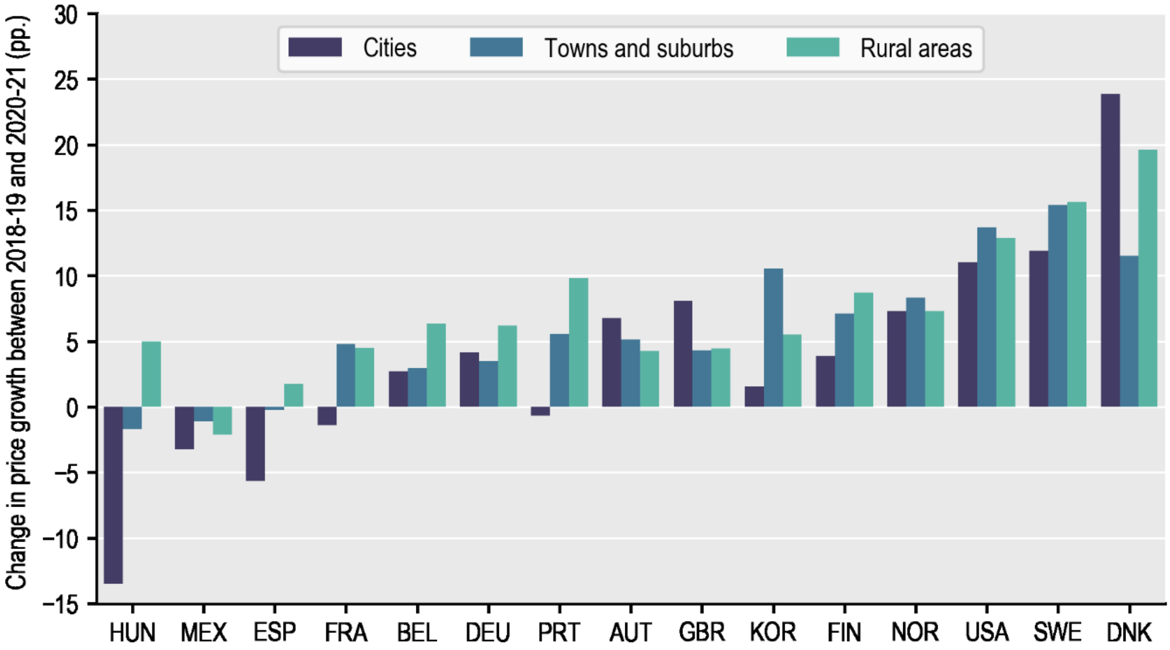


Note: Only geographical units located within large metropolitan areas and their buffers are included. Average house prices at the yearly level are obtained by taking the simple average across quarters. Price aggregates for the different rings are obtained by taking the population-weighted average house price across SAUs.

The shift in housing demand away from the metropolitan centres since the emergence of remote work might also be partially visible across settlements by degree of urbanisation. On average, within extended large metropolitan areas, house price growth accelerated more in towns and rural areas (6 and 7 pp, respectively) than in cities (3.5 pp) from 2018-2019 to 2020-2021. Only Austria, Denmark, and the UK recorded a higher price growth acceleration in cities than in other areas (Figure 3.6).

## Figure 3.6. House price growth rates from 2019 to 2021 by country and by degree of urbanisation in extended metropolitan areas

Price growth rate from 2020 to 2021 minus Price growth rate from 2018 to 2019, in percentage points



Note: Only geographical units located within large metropolitan areas and their buffers are included. Average house prices at the yearly level are obtained by taking the simple average across quarters. Price aggregates for the different types of settlements are obtained by taking the population-weighted average house price across SAUs.

These patterns provide a first statistical overview of house prices developments across metropolitan rings and types of settlements, before and during COVID-19. The following section provides a more precise assessment of shifts in housing demand across the different zones of the extended metropolitan areas, as well as by degree of urbanisation within each of the rings surrounding the large metropolitan centres. It does so through different econometric specifications estimating average house price growth differentials, while controlling for several confounders.

# 4

# Empirical specifications and results

### *Is the doughnut extending?*

A first question addressed in this section is whether, after the COVID-19 shock, house prices increased faster in areas outside the metropolitan centre and beyond metropolitan boundaries, i.e., in the commuting zones and in the outer rings (buffers). To this aim, a linear regression model was set up as in Equation 1:

$$\boldsymbol{\Delta(price_i) = \alpha * Commuting_i + \beta * Buffer1_i + \gamma * Buffer2_i + ExtMA_{j(i)} + Country_{c(i)} + \varepsilon_i} \qquad (1)$$

Where $\Delta(price_i)$ stands for house price changes (%) – based on annual average house prices – at SAU level (each SAU *i* is in an extended metropolitan area *j*, ExtMA). House price changes are regressed on a set of dummies ($Commuting_i$, $Buffer1_i$ and $Buffer2_i$) indicating if the SAU is in the commuting zone, the first buffer or the second buffer (where the reference group is the metropolitan core), while controlling for extended metropolitan area and country fixed effects (i.e., $ExtMA_{j(i)}$ and $Country_{c(i)}$). Country fixed effects are included to account for the cases in which some SAUs are in the buffer of another's country metropolitan area, e.g., a Hungarian SAU in the buffer of Vienna, Austria. To identify changes pre- and during COVID-19, the regressions are performed for yearly changes from 2018 to 2021.

The results of Equation 1 are presented in Table 4.1, where changes from 2018 to 2019 are denoted as changes in the pre-COVID-19 period. Price developments from 2019 to 2020 are considered as part of a period of transition from the pre-COVID-19 era to the new COVID-19 normality – referred to as the first year of COVID-19. This period includes the first COVID-19 outbreak and the strongest lockdowns. Finally, the period from 2020 to 2021 – denoted as the second year of COVID-19 – is understood as a period already reflecting most effects from COVID-19, including the normalisation of partial remote work.

**Table 4.1. Housing demand beyond the metropolitan centres**

Dependent variable: House price changes (%), for different periods

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Pre-COVID-19 2018-2019 | 1st year of COVID-19 2019-2020 | 2nd year of COVID-19 2020-2021 | Pre-COVID-19 2018-2019 | 1st year of COVID-19 2019-2020 | 2nd year of COVID-19 2020-2021 |
| Commuting zone | -0.186 | 0.200 | 0.992*** | -0.209 | 0.131 | 1.040*** |
| | (0.164) | (0.168) | (0.185) | (0.163) | (0.168) | (0.185) |
| Buffer 1 | 0.180 | -0.121 | 0.579*** | 0.075 | -0.212 | 0.622*** |
| | (0.139) | (0.135) | (0.151) | (0.139) | (0.135) | (0.151) |
| Buffer 2 | 0.211 | 0.040 | 0.339** | 0.027 | -0.166 | 0.435*** |
| | (0.159) | (0.152) | (0.166) | (0.159) | (0.151) | (0.166) |
| Ext. MA FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Country FE | No | No | No | Yes | Yes | Yes |
| Observations | 29,524 | 29,524 | 29,524 | 29,524 | 29,524 | 29,524 |
| Adjusted R2 | 0.109 | 0.053 | 0.174 | 0.114 | 0.061 | 0.176 |

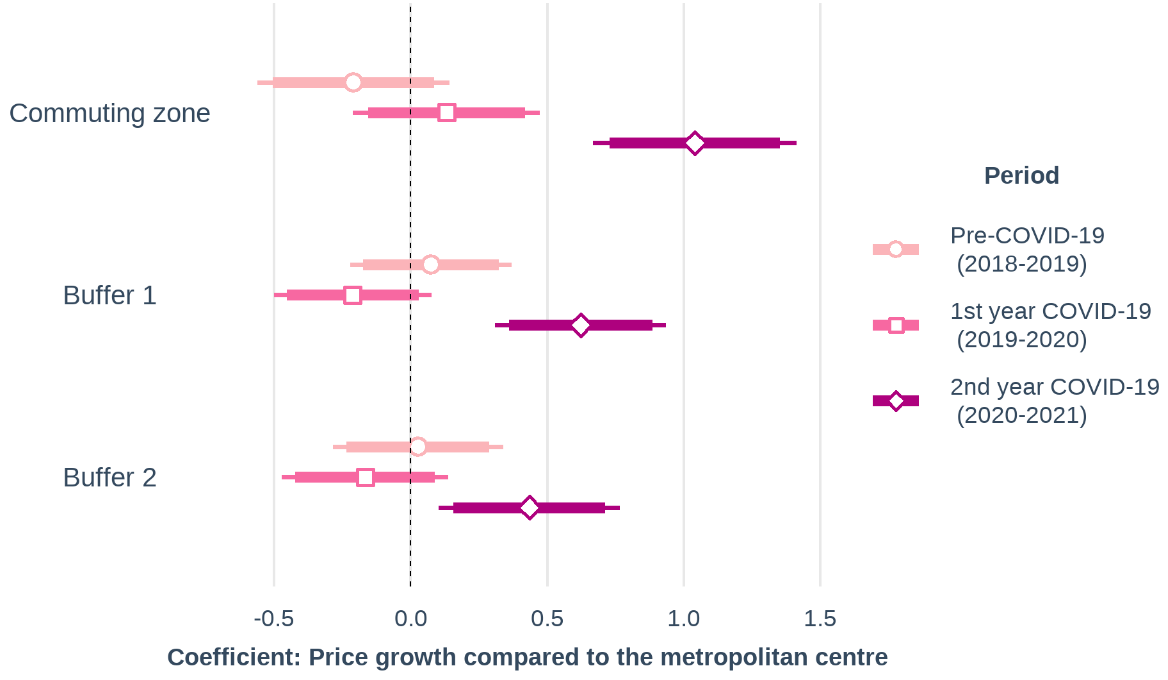
Note: *p<0.1; **p<0.05; ***p<0.01. Robust standard errors.

Overall, the results of this specification show that when most COVID-19 lockdowns ended (from 2020 to 2021), house prices started increasing faster outside metropolitan centres, even beyond the metropolitan boundaries (Table 4.1). The effects are statistically significant (at the 99%) for all the rings, and particularly large for commuting zones. The coefficients of interest are robust to the inclusion of country fixed effects (on top of extended metropolitan area fixed effects, Table 4.1, Columns 4 to 6). In addition, country fixed effects seem to slightly improve the model fit – as they might capture some time-invariant effects associated to the country of origin (including some national housing market characteristics).

Although series of year-to-year price growth at the SAU level could appear to be noisy, some patterns emerge from the estimation of Equation 1. First, before COVID-19 hit (and even during the COVID-19 early phase), house price growth was either lower or non-statistically different in the rings (commuting zones and buffers) compared to metropolitan cores. Second, from 2020 to 2021, house prices started increasing faster in the surroundings of metropolitan cores, including in the commuting zones and in the buffers. Third, average effects seem to decrease with the average distance of the ring to the metropolitan core (although differences between subsequent rings do not seem statistically different at the 95%). While the growth differential in commuting zones was around 1 pp (percentage points) relative to the city centre, the growth differentials in buffer 1 and buffer 2 were, respectively, around 0.6 and 0.4 pp (Figure 4.1). Overall results are robust to excluding specific countries from the sample (such as the UK, for which house prices are not expressed as per square metre), and to splitting the sample between Europe and the US (see Annex C).

## Figure 4.1. During the COVID-19 period, prices grew faster outside the metropolitan centres

Regression coefficients from Equation 1: Price growth differentials in percentage points



Note: Inner segment represents confidence intervals at the 90%, while whole segment covers confidence intervals at the 95%.

### *Within the extended doughnut, who is experiencing higher housing demand?*

A second set of regressions explores what are the places – by degree of urbanisation – experiencing higher home ownership demand within each ring in the surroundings of metropolitan centres. This is expressed through Equation 2, where, for each ring (commuting zone, buffer 1 and buffer 2) separately, house price changes (%) at SAU level are regressed on dummies for both cities and rural areas (where the reference group is towns), while controlling for extended metropolitan area and country fixed effects. These regressions are also tested using different periods (see Table 4.2).

$$\boldsymbol{\Delta(price_i) = \delta * Cities_i + \theta * RuralAreas_i + ExtMA_{j(i)} + Country_{c(i)} + \varepsilon_{i,j}} \qquad (2)$$

## Table 4.2. Housing demand in each ring, by degree of urbanisation

Dependent variable: House price changes (%), for different periods

| | In commuting zone | | | In buffer 1 | | | In buffer 2 | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| | Pre-COVID-19 2018-2019 | 1st year of COVID-19 2019-2020 | 2nd year of COVID-19 2020-2021 | Pre-COVID-19 2018-2019 | 1st year of COVID-19 2019-2020 | 2nd year of COVID-19 2020-2021 | Pre-COVID-19 2018-2019 | 1st year of COVID-19 2019-2020 | 2nd year of COVID-19 2020-2021 |
| Cities | 0.693* | 0.078 | 0.319 | -0.045 | -0.390 | 1.405*** | 0.766** | 0.448 | 1.574*** |
| | (0.382) | (0.412) | (0.411) | (0.278) | (0.269) | (0.281) | (0.339) | (0.300) | (0.315) |
| Rural areas | 0.129 | 1.131*** | 0.830** | 0.113 | 0.070 | 0.893*** | 0.013 | 0.088 | 0.455 |
| | (0.319) | (0.326) | (0.356) | (0.289) | (0.267) | (0.281) | (0.354) | (0.317) | (0.341) |
| Ext. MA FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 5,051 | 5,051 | 5,051 | 8,395 | 8,395 | 8,395 | 6,898 | 6,898 | 6,898 |
| Adjusted R2 | 0.178 | 0.056 | 0.203 | 0.104 | 0.061 | 0.194 | 0.082 | 0.076 | 0.163 |

Note: *p<0.1; **p<0.05; ***p<0.01. Robust standard errors.

The results of estimating this specification for SAUs in commuting zones suggest that since the start of COVID-19, rural areas close to metropolitan cores have gained attractiveness in terms of housing demand compared to towns. This is in contrast with the pre-pandemic period when price growth in rural areas was not significantly different to towns (Table 4.2, Columns 1 to 3). More precisely, in the first year of COVID-19 (2019-2020), house prices jumped in rural areas located in commuting zones and kept increasing faster than in towns even when most lockdowns were removed and vaccination campaigns were taking place (2020-2021) (see Figure 4.2).

## Figure 4.2. In commuting zones, rural areas had higher housing demand since COVID-19 hit

Regression coefficients from Equation 2: Price growth differentials within commuting zones, in percentage points

Note: Inner segment represents confidence intervals at the 90%, while whole segment covers confidence intervals at the 95%.

In the buffers, house prices increased faster in both cities and rural areas relative to towns during COVID-19, but differently depending on distance to the metropolitan boundaries. Table 4.2, Columns 4 to 6 show that within the first buffers, the space at the edge of the metropolitan boundaries next to the commuting zones, both cities and rural areas experienced higher increases in home ownership demand during the second year of COVID-19 (2020-2021) compared to towns. For rural areas in the closest buffers (first buffers), this pattern is similar to that observed in the commuting zones. However, the effect disappears when moving to farther away rings (second buffers) (Table 4.2, Columns 7 to 9).

At farther distance from the metropolitan boundaries, within second buffers, house prices have been growing faster in cities compared to towns. However, this trend is not necessarily specific to the COVID-19 period as it also occurred before the pandemic (Table 4.2, Columns 7 to 9). This suggests that, overall, outside metropolitan areas people start valuing access to more density at larger distances from the metropolitan cores. Indeed, these (smaller) cities outside the metropolitan boundaries provide people with access to services and urban amenities that would otherwise be too far, regardless of the new forms of work arrangements accelerated by the pandemic (for better visualisation of the estimates in the buffers, see Figure 4.3 and Figure 4.4).

## Figure 4.3. In buffer 1, house prices increased the most in cities, from 2020 to 2021

Regression coefficients from Equation 2: Price growth differentials within 1st buffers, in percentage points

Note: Inner segment represents confidence intervals at the 90%, while whole segment covers confidence intervals at the 95%.

## Figure 4.4. In buffer 2, housing demand has been rising in cities, but even pre-pandemic

Regression coefficients from Equation 2: Price growth differentials within 2nd buffers, in percentage points

Note: Inner segment represents confidence intervals at the 90%, while whole segment covers confidence intervals at the 95%.

Finally, when including the initial price as an extra control in Equation 2[4], the significance and sense of the coefficients of interest (i.e., being a city, or a rural area, relative to a town) hold for the buffers but not for the commuting zones. In this sense, the results of Table 4.2 and Table 4.3 (Columns 1 to 3) for commuting zones suggest that after COVID-19, less expensive places in terms of housing – which also tended to be rural areas – are the ones gaining more home ownership demand. Overall, initial house prices are negatively and significantly related to house price growth, which to some extent might denote a convergence pattern (places with initial low prices can grow at faster rates) that became stronger during COVID-19 and the rise of remote work, and to some degree a relative shift in preferences in the COVID-19 period towards more affordable and rural areas in the commuting zones, and towards (smaller) cities in the first buffers.

## Table 4.3. Housing demand in each ring, by degree of urbanisation and initial house price

| | In commuting zone | | | In buffer 1 | | | In buffer 2 | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| | Pre-COVID-19 2018-2019 | 1st year of COVID-19 2019-2020 | 2nd year of COVID-19 2020-2021 | Pre-COVID-19 2018-2019 | 1st year of COVID-19 2019-2020 | 2nd year of COVID-19 2020-2021 | Pre-COVID-19 2018-2019 | 1st year of COVID-19 2019-2020 | 2nd year of COVID-19 2020-2021 |
| Initial house price | -0.166*** | -0.172*** | -0.204*** | -0.168*** | -0.131*** | -0.144*** | -0.162*** | -0.137*** | -0.125*** |
| | (0.016) | (0.017) | (0.019) | (0.016) | (0.013) | (0.012) | (0.017) | (0.014) | (0.015) |
| Cities | 0.675* | 0.116 | 0.394 | -0.068 | -0.422 | 1.354*** | 0.760** | 0.450 | 1.582*** |
| | (0.382) | (0.408) | (0.399) | (0.274) | (0.266) | (0.277) | (0.339) | (0.297) | (0.314) |
| Rural areas | -0.522* | 0.406 | -0.020 | -0.024 | -0.055 | 0.736*** | -0.191 | -0.100 | 0.279 |
| | (0.314) | (0.321) | (0.349) | (0.289) | (0.266) | (0.279) | (0.365) | (0.321) | (0.344) |
| | | | | | | | | | |
| Ext. MA FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 5,051 | 5,051 | 5,051 | 8,395 | 8,395 | 8,395 | 6,898 | 6,898 | 6,898 |
| Adjusted R2 | 0.200 | 0.083 | 0.231 | 0.127 | 0.079 | 0.211 | 0.100 | 0.091 | 0.175 |

Note: Initial house price is normalised from 0 to 100, where 100 is the highest house price in the extended metropolitan area. *p<0.1; **p<0.05; ***p<0.01. Robust standard errors.

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[4] Initial house prices are not included as controls in Equation 1 since they are highly correlated with distance to the FUA centre (the relationship known as the house price-to-distance gradient), which is already captured through the dummies for the different spatial rings (i.e., adding initial house prices would introduce severe multicollinearity issues in this model). In Equation 2, where regressions are performed separately for each ring, initial house prices can enter the model as controls since distance to the city centre is relatively constant for all the SAUs located in the same ring.

# 5 Conclusion

In many large metropolitan areas, the COVID-19 pandemic and the emergence of working from home practices have slowed down housing demand in metropolitan centres, relative to other areas. This paper shows that when most COVID-19 lockdowns ended, house prices in the commuting zones and outer rings of large metropolitan areas started increasing faster compared to the metropolitan cores. This shift in home ownership demand was particularly pronounced in the commuting zones and, although it decreases with distance to the metropolitan centre, it remained significant even in faraway buffers. The observed trends reflect an "extended doughnut" effect, suggesting an enlargement of the area of influence of metropolitan areas.

The use of the degree of urbanisation to characterise space at more granular scales allowed identifying the characteristics of places experiencing a shift in housing demand. Such a shift was likely driven by a willingness to move to low-density – and more affordable – areas while keeping a certain proximity to urban services and amenities. Results suggest that people were keen on moving to less expensive housing in rural areas if they could benefit from the proximity to a large metropolitan centre. When moving farther away from a metropolitan centre, preferences shift to cities rather than to rural areas to ensure a certain level of urban benefits.

Further work could investigate the types of infrastructures, services and amenities driving these trends in housing demand within the "extended doughnut". Indeed, the accessibility to transport networks and digital infrastructures – including proximity to train stations, public transport costs and performance (ITF, 2019[25]), and Internet speed (OECD, 2021[26]) – as well as the availability of key amenities such as healthcare facilities and schools, could help explain the attractiveness of certain places in zones relatively far from the commuting zones. Finally, as this work analyses changes in the geography of housing demand only for the first two years of COVID-19, future work should also document the persistency of those trends and its consequences on a potential new spatial equilibrium (a new configuration of rural and urban spaces and their linkages) within and beyond metropolitan areas (OECD, 2021[27]).

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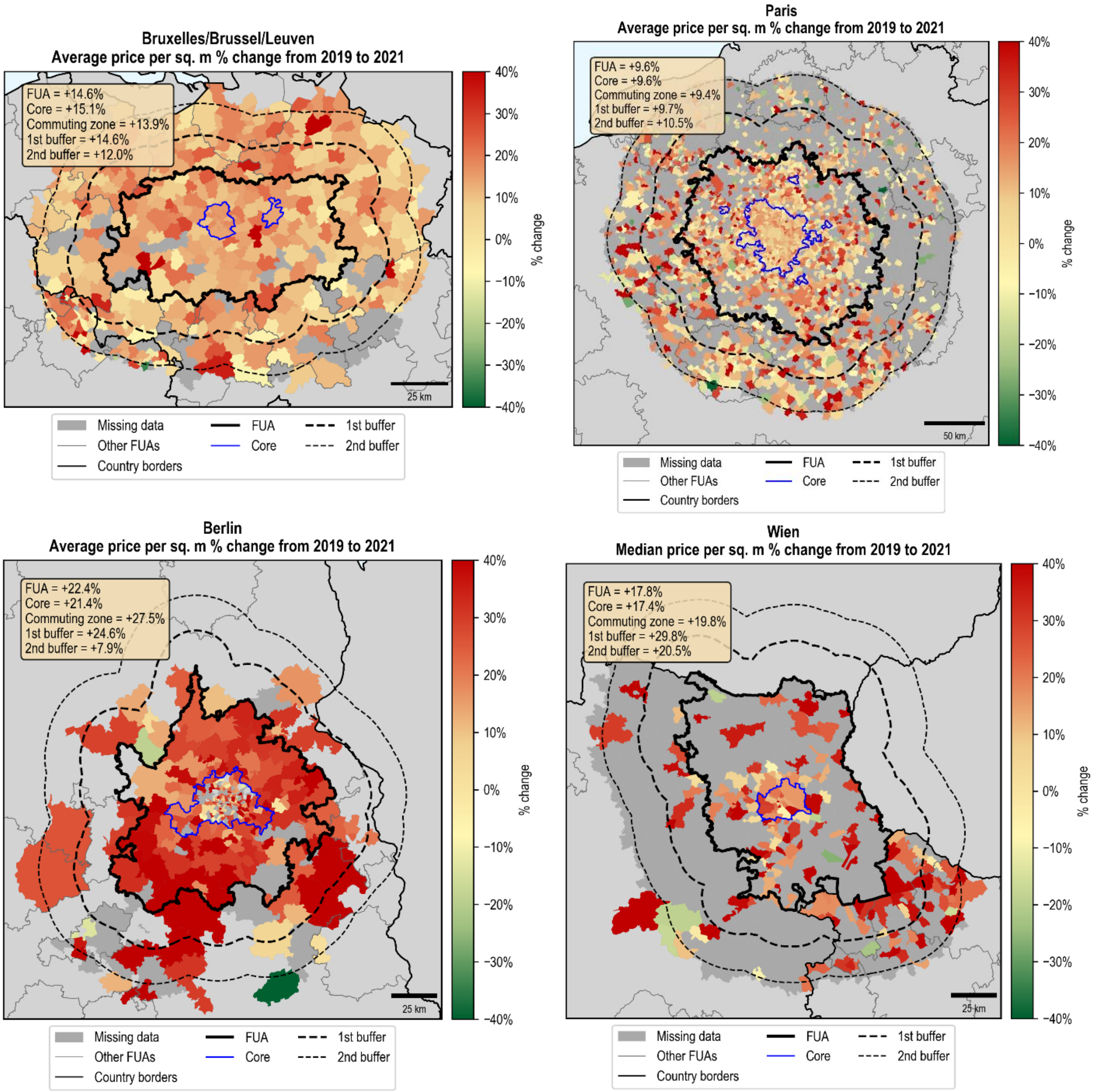
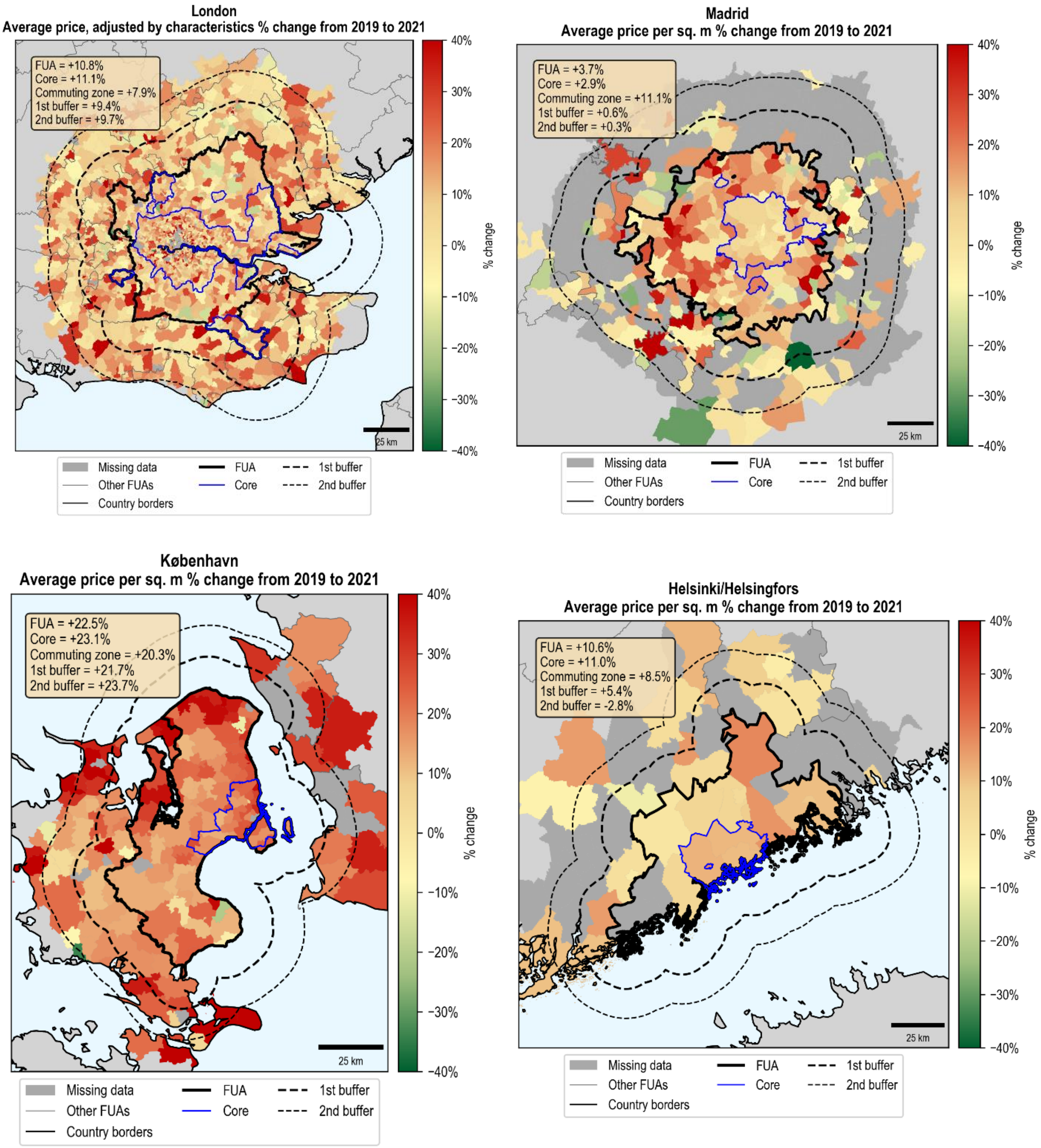
# Annex A. Evolution of house prices in selected extended large metropolitan areas

Figure A.1. House price changes from 2019 to 2021 in Brussels, Paris, Berlin and Vienna.



Note: House price change is the percentage change in yearly average house prices. The yearly average house price is obtained at the SAU level by taking the simple average across quarters. Price aggregates for the metropolitan areas (FUA), the cores and the different rings are obtained by taking the population weighted average house price across SAUs.

## Figure A.2. House price changes from 2019 to 2021 in London, Copenhagen, Madrid and Helsinki.



London
Average price, adjusted by characteristics % change from 2019 to 2021

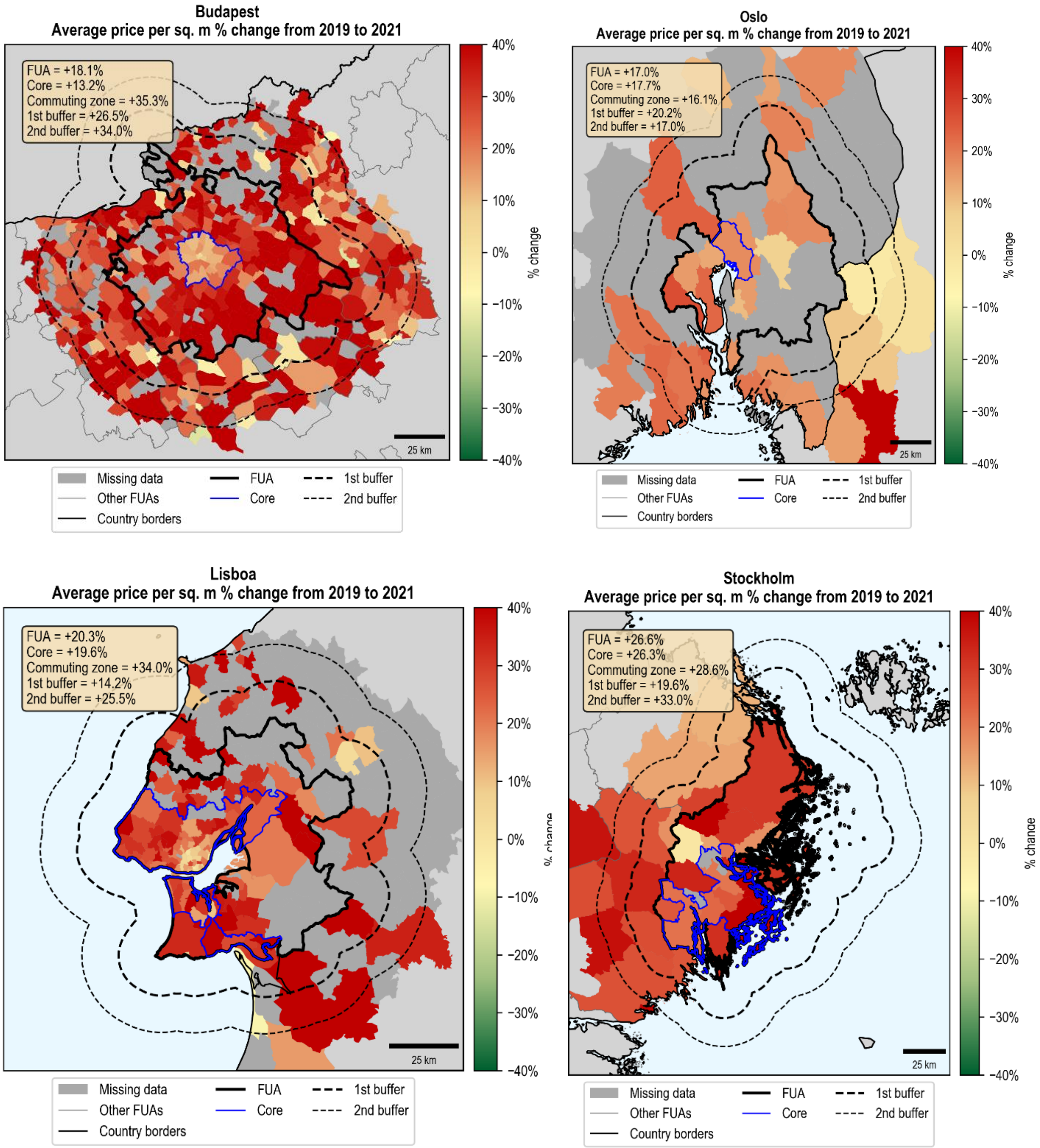
Madrid
Average price per sq. m % change from 2019 to 2021

København
Average price per sq. m % change from 2019 to 2021

Helsinki/Helsingfors
Average price per sq. m % change from 2019 to 2021

Note: House price change is the percentage change in yearly average house prices. The yearly average house price is obtained at the SAU level by taking the simple average across quarters. Price aggregates for the metropolitan areas (FUA), the cores and the different rings are obtained by taking the population weighted average house price across SAUs.

## Figure A.3. House price changes from 2019 to 2021 in Budapest, Oslo, Lisbon and Stockholm.

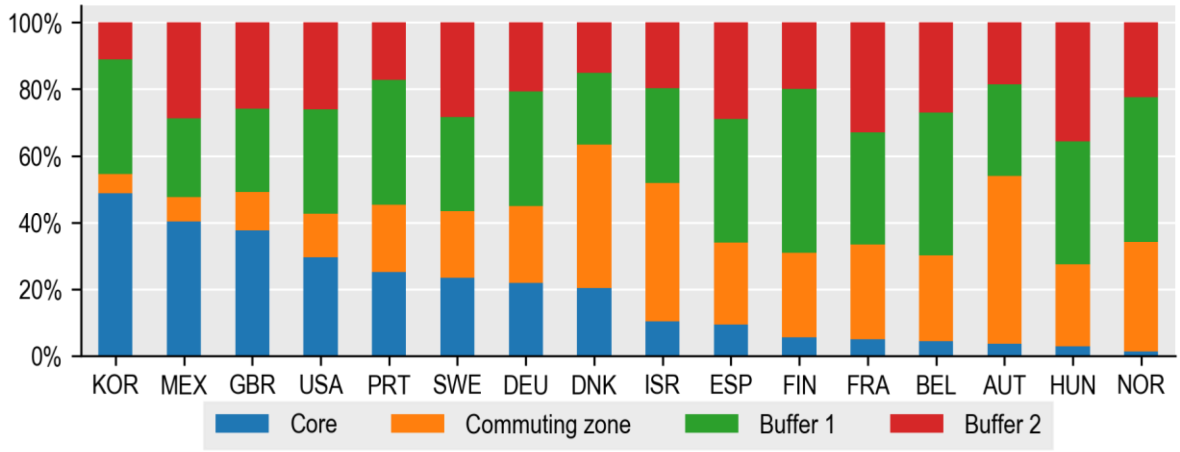


Note: House price change is the percentage change in yearly average house prices. The yearly average house price is obtained at the SAU level by taking the simple average across quarters. Price aggregates for the metropolitan areas (FUA), the cores and the different rings are obtained by taking the population weighted average house price across SAUs.

# Annex B. Complementary descriptive statistics

## Figure B.1. SAU distribution by zone

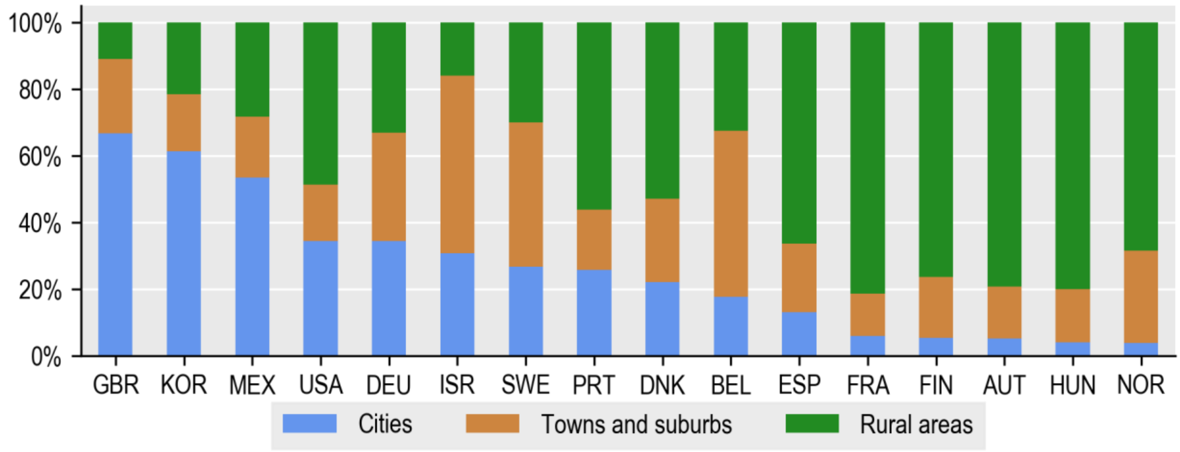
Share of geographical units across extended large metropolitan areas (core, commuting zone, and buffers)



Note: Only geographical units located within large metropolitan areas and their buffers are included.

## Figure B.2. SAU distribution by degree of urbanisation

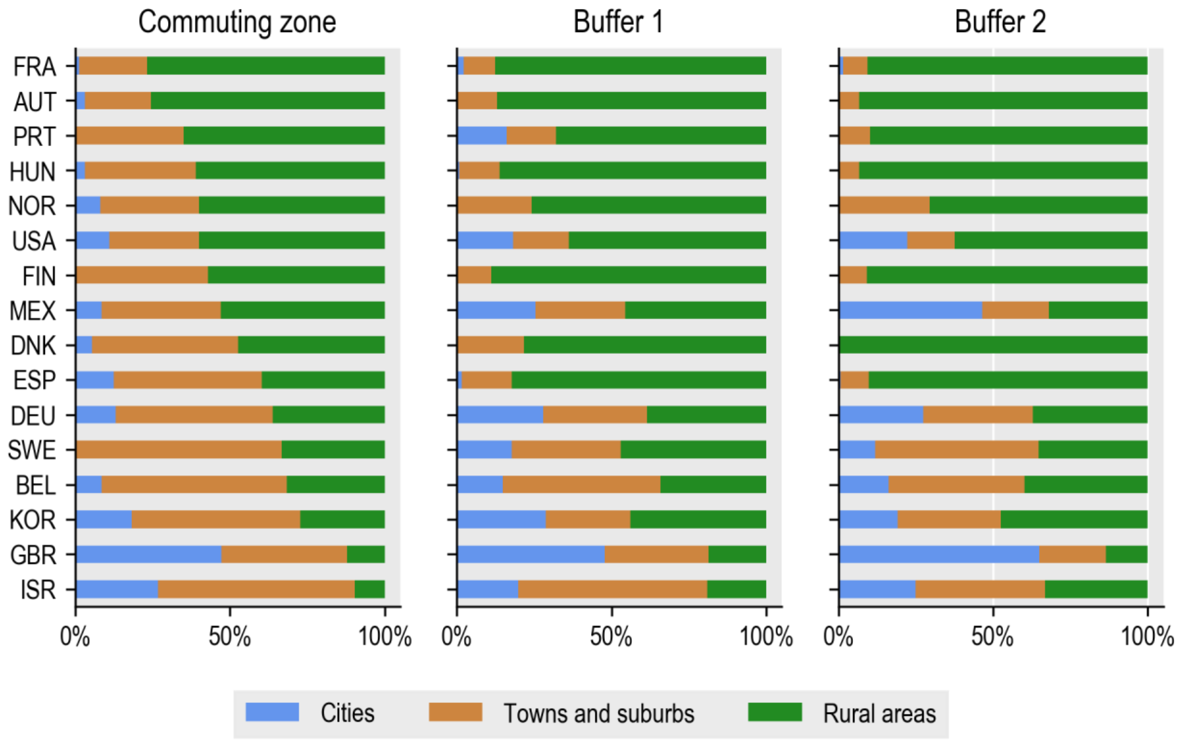
Share of geographical units across degrees of urbanisation in large metropolitan areas plus their buffers



Note: Only geographical units located within large metropolitan areas and their buffers are included.

## Figure B.3. SAU distribution by metropolitan ring and degree of urbanisation

Share of geographical units across degrees of urbanisation for different zones in extended metropolitan areas



Note: Only geographical units located within large metropolitan areas and their buffers are included.

## Table B.1. House prices statistics by large metropolitan area and by ring in Europe

Average prices per m$^2$ in 2021 (EUR)

| Country | Metropolitan area name | Large metropolitan area | Large metropolitan area and buffers | SAU bottom 10% | SAU median | SAU top 10% | Core | Commuting zone | 1st buffer | 2nd buffer |
|---|---|---|---|---|---|---|---|---|---|---|
| **Austria** | **Wien** | 4 641 | 4 197 | 397 | 2 167 | 5 623 | 5 049 | 3 343 | 1 638 | 1 164 |
| **Belgium** | **Brussels** | 2 662 | 2 193 | 1 091 | 1 865 | 3 098 | 3 090 | 2 225 | 1 933 | 1 763 |
| **Germany** | **Berlin** | 4 617 | 4 397 | 1 525 | 3 969 | 6 698 | 4 932 | 3 455 | 1 882 | 1 447 |
| | **Hamburg** | 4 398 | 3 660 | 1 542 | 2 653 | 6 804 | 5 425 | 3 346 | 2 577 | 2 366 |
| | **München** | 8 130 | 6 845 | 2 776 | 5 013 | 10 521 | 8 889 | 6 712 | 4 478 | 3 626 |
| | **Köln** | 3 750 | 3 260 | 1 689 | 2 914 | 5 532 | 4 050 | 3 026 | 2 935 | 3 052 |
| | **Frankfurt am Main** | 4 527 | 3 809 | 1 580 | 2 942 | 6 216 | 5 537 | 3 612 | 3 323 | 2 395 |
| | **Ruhrgebiet** | 2 200 | 2 525 | 1 568 | 2 274 | 4 505 | 2 199 | 2 203 | 2 725 | 3 001 |
| | **Stuttgart** | 4 267 | 3 760 | 2 345 | 3 418 | 4 985 | 4 724 | 3 900 | 3 202 | 2 991 |
| | **Düsseldorf** | 3 892 | 3 060 | 1 640 | 2 674 | 5 255 | 4 372 | 3 115 | 2 716 | 2 763 |
| **Denmark** | **Copenhagen** | 5 191 | 4 624 | 1 116 | 2 911 | 7 034 | 5 970 | 3 621 | 3 066 | 3 154 |
| **Spain** | **Madrid** | 2 571 | 2 455 | 421 | 1 077 | 3 133 | 2 754 | 1 675 | 1 005 | 595 |
| | **Barcelona** | 2 747 | 2 598 | 855 | 1 731 | 3 427 | 2 909 | 2 126 | 1 331 | 1 497 |
| | **Valencia** | 1 330 | 1 233 | 489 | 835 | 1 616 | 1 383 | 1 111 | 806 | 705 |
| **Finland** | **Helsinki** | 4 142 | 3 683 | 1 047 | 1 944 | 4 716 | 4 680 | 2 501 | 1 598 | 1 697 |
| **France** | **Paris** | 5 926 | 5 330 | 1 159 | 2 308 | 6 178 | 6 383 | 3 056 | 2 055 | 1 960 |
| | **Lyon** | 4 044 | 3 389 | 1 283 | 2 315 | 4 738 | 4 482 | 3 261 | 1 941 | 1 886 |
| | **Lille** | 2 700 | 2 075 | 1 165 | 1 777 | 3 247 | 2 866 | 2 396 | 1 551 | 1 574 |
| | **Marseille** | 3 415 | 3 406 | 2 084 | 3 430 | 5 698 | 3 158 | 4 018 | 3 332 | 3 523 |
| | **Toulouse** | 3 007 | 2 573 | 1 023 | 1 763 | 3 356 | 3 388 | 2 614 | 1 709 | 1 419 |
| **Hungary** | **Budapest** | 1 739 | 1 469 | 166 | 525 | 1 921 | 1 969 | 1 296 | 768 | 473 |
| **Norway** | **Oslo** | 6 840 | 5 786 | 1 134 | 3 416 | 6 782 | 8 759 | 5 190 | 3 233 | 2 684 |
| **Portugal** | **Lisbon** | 2 371 | 2 358 | 910 | 1 676 | 4 597 | 2 451 | 1 488 | 2 356 | 1 172 |
| **Sweden** | **Stockholm** | 6 572 | 5 818 | 2 515 | 3 880 | 8 309 | 6 955 | 4 773 | 3 357 | 3 121 |

Note: Average house prices at the yearly level are obtained by taking the simple average across quarters. Price aggregates for the different rings are obtained by taking the population-weighted average house price across SAUs.

## Table B.2. House prices statistics by large metropolitan area and by ring in Israel, Korea and Mexico

Average prices per m² in 2021 (local currency)

| Country | Metropolitan area name | Large metropolitan area | Large metropolitan area and buffers | SAU bottom 10% | SAU median | SAU top 10% | Core | Commuting zone | 1st buffer | 2nd buffer |
|---|---|---|---|---|---|---|---|---|---|---|
| **Israel** | **Tel Aviv - Yafo** | 26 312 | 25 285 | 12 895 | 20 850 | 34 564 | 26 782 | 22 432 | 18 294 | 25 480 |
| **Korea** | **Seoul** | 7 990 140 | 7 320 268 | 1 587 155 | 4 962 543 | 14 731 041 | 8 331 817 | 4 852 823 | 2 813 224 | 1 984 308 |
| | **Gimhae** | 3 905 797 | 3 561 894 | 1 667 486 | 2 934 366 | 5 322 880 | 3 965 789 | 3 173 782 | 3 094 827 | 2 284 972 |
| | **Dalseong** | 4 084 136 | 3 481 306 | 1 435 474 | 2 066 201 | 6 540 073 | 4 084 136 | | 1 945 406 | 2 091 648 |
| | **Gwangsan** | 3 328 170 | 2 870 781 | 1 083 679 | 1 611 160 | 3 726 090 | 3 401 230 | 1 960 215 | 1 879 005 | 1 561 764 |
| | **Seo** | 3 799 426 | 3 279 797 | 1 537 493 | 2 433 680 | 5 576 021 | 3 799 426 | | 2 569 844 | 2 652 824 |
| **Mexico** | **Mexico City** | 22 612 | 21 658 | 9 756 | 20 042 | 51 376 | 22 681 | 11 288 | 12 423 | 14 264 |
| | **Guadalajara** | 17 461 | 17 434 | 9 447 | 17 360 | 38 581 | 18 266 | 13 505 | 12 952 | 12 055 |
| | **Monterrey** | 13 320 | 13 062 | 9 246 | 12 847 | 36 878 | 13 509 | 10 904 | 11 647 | 10 958 |
| | **Puebla** | 13 367 | 12 724 | 8 490 | 11 948 | 20 716 | 13 326 | 16 284 | 9 929 | 8 948 |
| | **Toluca** | 14 036 | 27 430 | 10 860 | 26 187 | 58 134 | 14 245 | 12 841 | 33 328 | 31 290 |
| | **Tijuana** | 17 703 | 17 651 | 11 871 | 15 576 | 35 339 | 17 703 | | 13 539 | 14 032 |
| | **Leon** | 11 389 | 11 410 | 7 644 | 11 460 | 21 417 | 11 389 | | 13 112 | 11 350 |
| | **Queretaro** | 16 329 | 14 024 | 8 642 | 12 872 | 25 245 | 16 428 | 15 280 | 10 714 | 11 996 |
| | **Torreon** | 8 947 | 8 899 | 6 728 | 8 418 | 14 614 | 8 947 | | 8 159 | |

Note: Prices are expressed in local currency: Exchange rates for Israeli New Shekel (1 ISL = 0.26 USD), Mexican Pesos (1 MXN = 0.0417 USD), and South Korean Won (1 KRW = 0.000739 USD). Average house prices at the yearly level are obtained by taking the simple average across quarters. Price aggregates for the different rings are obtained by taking the population-weighted average house price across SAUs.

## Table B.3. House prices statistics by large metropolitan area and by ring in the UK

Average prices in 2021 (GBP)

| Metropolitan area name | Large metropolitan area | Large metropolitan area and buffers | SAU bottom 10% | SAU median | SAU top 10% | Core | Commuting zone | 1st buffer | 2nd buffer |
|---|---|---|---|---|---|---|---|---|---|
| **London** | 636 438 | 564 629 | 267 191 | 446 553 | 1 075 933 | 656 840 | 511 039 | 408 549 | 358 865 |
| **West Midlands urban area** | 215 254 | 225 481 | 146 146 | 222 766 | 408 524 | 206 612 | 261 781 | 235 297 | 265 104 |
| **Leeds** | 198 425 | 210 119 | 112 897 | 206 215 | 401 633 | 186 386 | 251 340 | 202 099 | 223 606 |
| **Liverpool** | 189 064 | 190 902 | 98 379 | 188 056 | 402 394 | 190 006 | 185 017 | 192 632 | 194 740 |
| **Manchester** | 228 947 | 202 757 | 103 881 | 194 688 | 396 674 | 221 868 | 280 369 | 204 954 | 177 577 |

Note: Average house prices at the yearly level are obtained by taking the simple average across quarters. Price aggregates for the different rings are obtained by taking the population-weighted average house price across SAUs.

## Table B.4. House prices statistics by large metropolitan area and by ring in the US

Average prices in 2021 (USD)

| Metropolitan area name | Large metropolitan area | Large metropolitan area and buffers | SAU bottom 10% | SAU median | SAU top 10% | Core | Commuting zone | 1st buffer | 2nd buffer |
|---|---|---|---|---|---|---|---|---|---|
| **New York (Greater)** | 692 159 | 577 673 | 147 277 | 396 406 | 1 319 280 | 711 386 | 433 169 | 380 062 | 285 884 |
| **Los Angeles (Greater)** | 795 027 | 747 037 | 199 409 | 642 556 | 2 011 946 | 795 027 | | 679 740 | 595 262 |
| **Chicago** | 296 637 | 279 009 | 88 847 | 222 757 | 545 868 | 301 052 | 260 743 | 265 599 | 207 400 |
| **Washington (Greater)** | 506 516 | 427 527 | 148 153 | 322 588 | 833 426 | 530 201 | 424 589 | 282 697 | 294 941 |
| **San Francisco (Greater)** | 1 440 492 | 1 155 898 | 337 507 | 979 151 | 2 827 179 | 1 441 716 | 1 398 542 | 729 429 | 512 733 |
| **Philadelphia (Greater)** | 312 835 | 347 899 | 152 647 | 326 739 | 846 634 | 289 089 | 370 094 | 334 526 | 426 036 |
| **Dallas** | 335 026 | 308 642 | 89 380 | 213 574 | 519 370 | 343 181 | 287 344 | 183 192 | 162 127 |
| **Houston** | 279 623 | 269 816 | 118 080 | 214 287 | 513 102 | 278 341 | 284 611 | 204 818 | 196 935 |
| **Miami (Greater)** | 362 569 | 366 860 | 169 932 | 351 764 | 895 065 | 361 388 | 402 421 | 410 378 | 309 117 |
| **Atlanta** | 334 264 | 306 938 | 106 883 | 233 892 | 520 138 | 349 274 | 320 100 | 247 067 | 159 380 |
| **Boston** | 704 817 | 580 498 | 280 811 | 479 635 | 1 276 730 | 723 549 | 521 441 | 421 439 | 373 449 |
| **Phoenix** | 396 350 | 377 601 | 138 747 | 348 055 | 778 250 | 403 411 | 341 765 | 285 931 | 371 093 |
| **Detroit (Greater)** | 222 950 | 217 033 | 61 831 | 208 262 | 431 938 | 218 760 | 257 976 | 220 995 | 162 443 |
| **Seattle** | 719 302 | 670 422 | 321 153 | 524 041 | 1 270 192 | 719 302 | | 590 310 | 482 301 |
| **Minneapolis** | 351 307 | 327 933 | 164 718 | 278 358 | 504 886 | 346 969 | 358 679 | 249 692 | 246 924 |
| **San Diego** | 794 534 | 793 630 | 303 467 | 693 260 | 2 241 217 | 794 534 | | 848 174 | 762 727 |
| **St. Louis** | 232 229 | 218 116 | 57 864 | 160 674 | 416 231 | 254 290 | 182 996 | 160 884 | 134 029 |
| **Denver** | 544 985 | 530 577 | 200 456 | 484 182 | 956 350 | 541 537 | 636 632 | 563 246 | 432 865 |
| **San Antonio** | 254 245 | 371 354 | 118 985 | 296 016 | 841 829 | 237 297 | 331 717 | 350 331 | 594 915 |
| **Portland** | 525 823 | 489 600 | 256 795 | 431 862 | 712 394 | 515 996 | 564 364 | 400 587 | 382 989 |
| **Cincinnati** | 239 848 | 212 763 | 87 231 | 179 439 | 352 842 | 228 003 | 249 397 | 180 724 | 163 743 |
| **Las Vegas** | 336 083 | 337 364 | 132 807 | 327 088 | 579 593 | 336 371 | 270 617 | 352 904 | 333 256 |
| **Orange** | 305 696 | 276 087 | 148 418 | 247 700 | 456 000 | 311 556 | 289 625 | 247 373 | 253 235 |
| **Jackson (MO)** | 266 992 | 238 589 | 70 216 | 164 317 | 406 379 | 270 904 | 255 783 | 183 746 | 135 203 |
| **Indianapolis** | 239 143 | 211 681 | 81 758 | 166 309 | 330 503 | 236 516 | 244 094 | 173 942 | 159 953 |
| **Cuyahoga** | 193 368 | 184 247 | 68 694 | 188 907 | 360 044 | 176 590 | 236 344 | 182 372 | 161 564 |
| **New Haven** | 415 582 | 528 024 | 195 763 | 474 435 | 1 443 746 | 279 461 | 560 773 | 589 140 | 548 428 |
| **Charlotte** | 338 689 | 289 054 | 75 044 | 208 614 | 533 399 | 361 421 | 306 970 | 220 316 | 178 972 |
| **Sacramento** | 521 621 | 700 823 | 277 895 | 530 503 | 1 582 588 | 514 747 | 616 734 | 634 027 | 890 894 |
| **Austin** | 545 161 | 428 357 | 153 409 | 351 543 | 865 868 | 557 260 | 421 468 | 299 522 | 280 602 |
| **Columbus** | 272 179 | 228 590 | 80 362 | 173 937 | 361 472 | 255 367 | 296 967 | 157 827 | 187 291 |
| **Milwaukee** | 236 480 | 239 822 | 126 003 | 256 276 | 454 360 | 175 932 | 350 248 | 260 469 | 202 866 |
| **Jacksonville** | 267 890 | 256 699 | 103 357 | 214 321 | 605 850 | 249 507 | 297 862 | 254 819 | 209 093 |
| **Salt Lake** | 514 221 | 490 255 | 238 186 | 438 404 | 830 651 | 507 548 | 622 318 | 474 222 | 340 507 |
| **Tampa-Pinellas** | 268 153 | 295 708 | 173 773 | 277 033 | 694 051 | 278 950 | 252 452 | 339 711 | 272 325 |
| **Tampa-Hillsborough** | 316 280 | 297 861 | 170 563 | 286 137 | 681 574 | 316 280 | | 296 020 | 272 106 |

Note: Average house prices at the yearly level are obtained by taking the simple average across quarters. Price aggregates for the different rings are obtained by taking the population-weighted average house price across SAUs.

## Table B.5. Price growth statistics by large metropolitan area and by ring

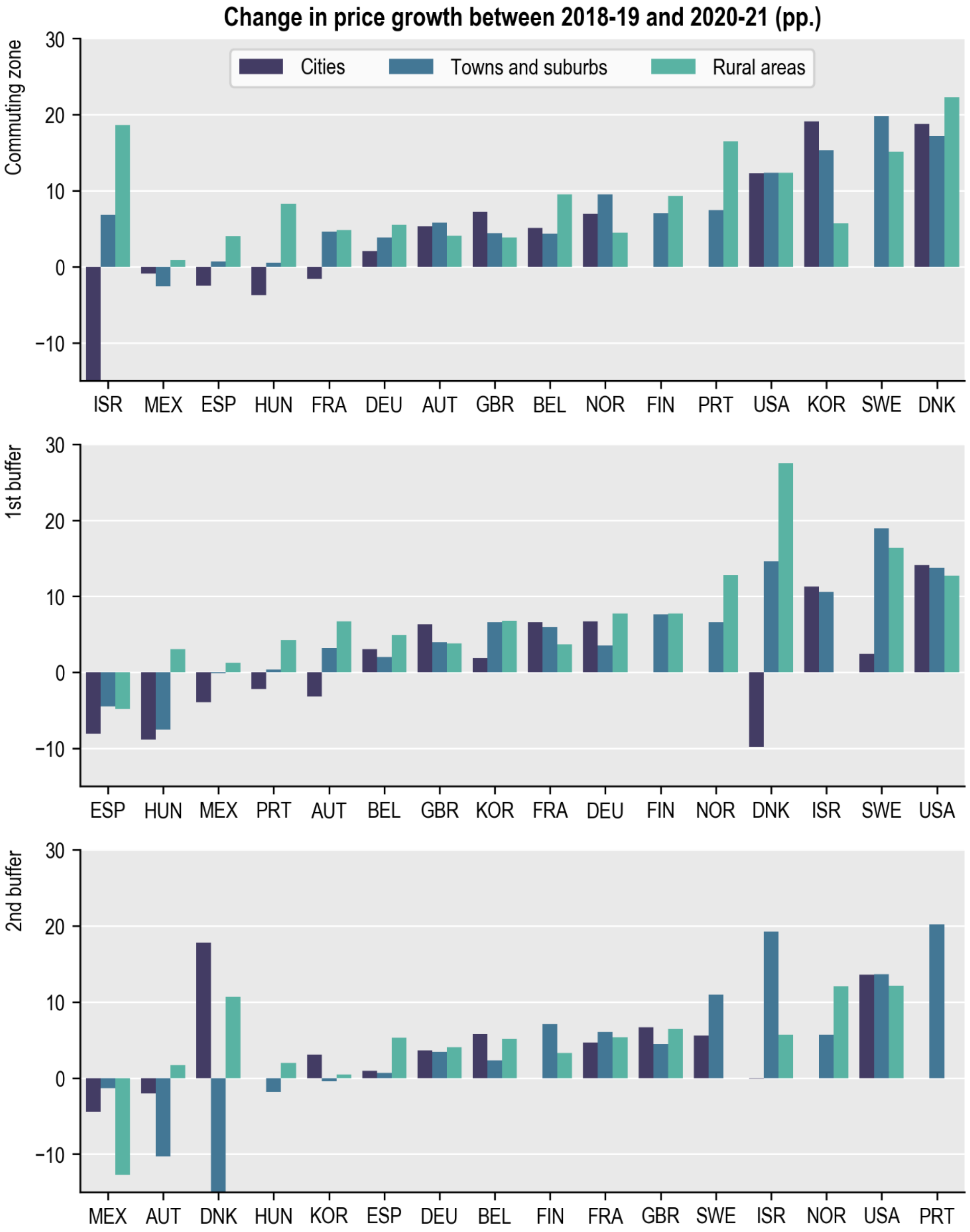
Average price per m² growth rates between 2019 and 2021.

| Country | Metropolitan area name | Large metropolitan area | Large metropolitan area and buffers | Core | Commuting zone | 1st buffer | 2nd buffer |
|---|---|---|---|---|---|---|---|
| Austria | Vienna | 17.8% | 18.2% | 17.4% | 19.8% | 29.8% | 20.5% |
| Belgium | Brussels | 14.6% | 14.1% | 15.1% | 13.9% | 14.6% | 12.0% |
| Germany | Berlin | 22.4% | 22.3% | 21.4% | 27.5% | 24.6% | 7.9% |
| | Hamburg | 22.6% | 24.2% | 21.5% | 24.5% | 30.1% | 26.0% |
| | München | 18.1% | 19.5% | 18.6% | 17.0% | 25.3% | 23.0% |
| | Köln | 25.5% | 26.1% | 25.3% | 26.1% | 26.5% | 26.6% |
| | Frankfurt am Main | 23.9% | 23.1% | 23.6% | 24.2% | 22.0% | 21.9% |
| | Ruhrgebiet | 21.5% | 23.4% | 21.1% | 23.0% | 24.6% | 25.2% |
| | Stuttgart | 20.5% | 21.3% | 19.6% | 21.3% | 22.0% | 24.5% |
| | Düsseldorf | 27.5% | 25.5% | 27.7% | 27.0% | 24.0% | 25.0% |
| Denmark | Copenhagen | 22.5% | 22.5% | 23.1% | 20.3% | 21.7% | 23.7% |
| Spain | Madrid | 3.7% | 3.6% | 2.9% | 11.1% | 0.6% | 0.3% |
| | Barcelona | 4.3% | 4.8% | 2.2% | 17.5% | 12.4% | 11.9% |
| | Valencia | 13.4% | 13.2% | 12.9% | 16.4% | 10.3% | 18.5% |
| Finland | Helsinki | 10.6% | 9.9% | 11.0% | 8.5% | 5.4% | -2.8% |
| France | Paris | 9.6% | 9.6% | 9.6% | 9.4% | 9.7% | 10.5% |
| | Lyon | 16.6% | 15.9% | 16.3% | 17.4% | 12.7% | 12.6% |
| | Lille | 12.7% | 11.9% | 12.5% | 13.2% | 11.4% | 9.1% |
| | Marseille | 8.0% | 9.1% | 6.4% | 11.1% | 10.8% | 13.6% |
| | Toulouse | 11.1% | 11.2% | 10.2% | 12.2% | 10.7% | 13.3% |
| Hungary | Budapest | 18.1% | 19.2% | 13.2% | 35.3% | 26.5% | 34.0% |
| Israel | Tel Aviv - Yafo | 11.0% | 10.3% | 11.3% | 8.9% | 12.8% | 7.0% |
| Korea | Seoul | 28.7% | 28.3% | 28.1% | 39.2% | 20.6% | 12.6% |
| | Gimhae | 15.3% | 15.2% | 15.3% | 15.3% | 16.3% | 8.3% |
| | Dalseong | 18.3% | 17.3% | 18.3% | | 4.8% | 25.6% |
| | Gwangsan | 19.7% | 17.8% | 19.6% | 23.9% | 11.1% | 7.1% |
| | Seo | 30.6% | 27.6% | 30.6% | | 25.5% | 16.4% |
| Mexico | Mexico City | 3.6% | 3.8% | 3.6% | 10.3% | 5.1% | 7.2% |
| | Guadalajara | 20.2% | 20.2% | 20.4% | 18.2% | 33.1% | 26.5% |
| | Monterrey | 17.5% | 17.5% | 17.5% | 18.5% | 15.7% | 17.2% |
| | Puebla | 11.5% | 11.3% | 11.5% | 9.8% | 10.9% | 8.3% |
| | Toluca | 0.4% | 0.7% | -0.4% | 6.0% | -3.7% | 1.3% |
| | Tijuana | 29.8% | 29.9% | 29.8% | | 37.6% | 31.2% |
| | Leon | 16.0% | 15.8% | 16.0% | | 20.1% | 9.6% |
| | Queretaro | 13.7% | 13.1% | 13.5% | 15.9% | 12.2% | 11.9% |
| | Torreon | 15.8% | 15.7% | 15.8% | | 13.2% | |
| Norway | Oslo | 17.0% | 17.2% | 17.7% | 16.1% | 19.7% | 17.0% |
| Portugal | Lisbon | 20.3% | 19.0% | 19.6% | 34.0% | 14.2% | 25.5% |
| Sweden | Stockholm | 26.6% | 26.3% | 26.3% | 28.6% | 19.6% | 33.0% |
| UK | London | 10.8% | 10.5% | 11.1% | 7.9% | 9.4% | 9.7% |
| | West Midlands urban area | 11.6% | 9.7% | 11.4% | 12.6% | 6.2% | 7.7% |
| | Leeds | 10.4% | 13.2% | 10.9% | 8.9% | 15.1% | 14.1% |
| | Liverpool | 13.9% | 12.2% | 13.6% | 15.1% | 10.9% | 8.7% |
| | Manchester | 14.1% | 12.9% | 14.7% | 10.6% | 12.1% | 12.0% |
| US | New York (Greater) | 5.6% | 8.1% | 5.1% | 16.5% | 20.9% | 21.1% |
| | Los Angeles | 20.6% | 21.6% | 20.6% | | 21.9% | 28.4% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **(Greater)** | | | | | | |
| | **Chicago** | 12.4% | 13.4% | 11.9% | 16.7% | 13.0% | 21.9% |
| | **Washington (Greater)** | 14.8% | 15.5% | 14.3% | 16.8% | 18.0% | 17.7% |
| | **San Francisco (Greater)** | 13.5% | 14.9% | 13.3% | 18.9% | 19.1% | 25.4% |
| | **Philadelphia (Greater)** | 19.6% | 18.7% | 19.8% | 19.2% | 19.6% | 16.9% |
| | **Dallas** | 20.6% | 20.1% | 20.5% | 21.2% | 17.3% | 14.1% |
| | **Houston** | 15.8% | 15.6% | 15.6% | 16.7% | 12.8% | 15.4% |
| | **Miami (Greater)** | 18.8% | 18.5% | 18.6% | 23.3% | 16.7% | 21.2% |
| | **Atlanta** | 22.9% | 22.7% | 20.9% | 25.0% | 22.7% | 19.2% |
| | **Boston** | 13.7% | 16.8% | 13.0% | 23.6% | 24.7% | 26.3% |
| | **Phoenix** | 40.1% | 39.1% | 40.2% | 40.0% | 33.9% | 34.1% |
| | **Detroit (Greater)** | 19.7% | 18.8% | 19.9% | 18.5% | 16.7% | 20.5% |
| | **Seattle** | 26.5% | 26.5% | 26.5% | | 26.6% | 26.5% |
| | **Minneapolis** | 16.6% | 16.9% | 15.0% | 19.4% | 18.8% | 17.8% |
| | **San Diego** | 29.5% | 25.3% | 29.5% | | 23.1% | 21.4% |
| | **St. Louis** | 17.7% | 17.3% | 17.9% | 17.0% | 16.4% | 11.5% |
| | **Denver** | 21.3% | 21.9% | 21.2% | 23.2% | 23.4% | 22.4% |
| | **San Antonio** | 18.5% | 30.2% | 18.4% | 18.8% | 30.4% | 41.1% |
| | **Portland** | 20.6% | 21.6% | 20.2% | 22.0% | 24.6% | 27.2% |
| | **Cincinnati** | 23.0% | 22.5% | 25.4% | 21.3% | 21.8% | 21.0% |
| | **Las Vegas** | 22.1% | 23.5% | 22.1% | 20.3% | 34.9% | 29.0% |
| | **Orange** | 20.4% | 22.5% | 20.4% | 20.3% | 24.0% | 25.8% |
| | **Jackson (MO)** | 20.5% | 20.3% | 20.7% | 20.0% | 19.6% | 18.0% |
| | **Indianapolis** | 23.0% | 21.8% | 23.3% | 22.4% | 19.5% | 19.2% |
| | **Cuyahoga** | 21.9% | 21.5% | 23.6% | 18.8% | 21.0% | 21.2% |
| | **New Haven** | 20.9% | 14.7% | 24.7% | 19.0% | 14.5% | 12.7% |
| | **Charlotte** | 28.5% | 27.2% | 27.4% | 30.2% | 25.3% | 20.4% |
| | **Sacramento** | 26.3% | 23.2% | 26.0% | 29.4% | 23.0% | 22.0% |
| | **Austin** | 42.7% | 34.9% | 43.1% | 37.1% | 23.1% | 17.7% |
| | **Columbus** | 22.1% | 21.4% | 24.2% | 19.4% | 19.5% | 20.8% |
| | **Milwaukee** | 22.8% | 21.8% | 26.5% | 19.6% | 20.4% | 19.3% |
| | **Jacksonville** | 24.4% | 23.3% | 25.7% | 22.7% | 21.7% | 21.6% |
| | **Salt Lake** | 32.4% | 32.8% | 32.5% | 31.1% | 34.2% | 27.4% |
| | **Tampa-Pinellas** | 32.5% | 29.8% | 32.1% | 33.2% | 28.4% | 29.1% |
| | **Tampa-Hillsborough** | 28.3% | 29.4% | 28.3% | | 29.5% | 31.3% |

Note: Average house prices at the yearly level are obtained by taking the simple average across quarters. Price aggregates for the different rings are obtained by taking the population-weighted average house price across SAUs.

Figure B.4. Change in house price growth rates between 2019-20 and 2020-21 by country, ring and degree of urbanisation



Note: Only geographical units located within large metropolitan areas and their buffers are included. Average house prices at the yearly level are obtained by taking the simple average across quarters. Price aggregates for the different types of settlements and rings are obtained by taking the population-weighted average house price across SAUs.

# Annex C. Robustness checks

## Table C.1. Robustness checks: Housing demand beyond the metropolitan centres

| | Excluding the UK | | | Only Europe | | | Only the US | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| | Pre-COVID-19 2018-2019 | 1st year of COVID-19 2019-2020 | 2nd year of COVID-19 2020-2021 | Pre-COVID-19 2018-2019 | 1st year of COVID-19 2019-2020 | 2nd year of COVID-19 2020-2021 | Pre-COVID-19 2018-2019 | 1st year of COVID-19 2019-2020 | 2nd year of COVID-19 2020-2021 |
| Commuting zone | -0.135 | 0.170 | 1.851*** | -0.314 | 1.154*** | 2.464*** | -0.006 | -0.286*** | 1.548*** |
| | (0.163) | (0.166) | (0.186) | (0.371) | (0.381) | (0.400) | (0.094) | (0.084) | (0.139) |
| Buffer 1 | 0.054 | -0.162 | 1.208*** | -0.400 | 0.464 | 1.557*** | 0.420*** | -0.203*** | 1.219*** |
| | (0.137) | (0.126) | (0.147) | (0.465) | (0.427) | (0.441) | (0.077) | (0.071) | (0.123) |
| Buffer 2 | -0.058 | 0.096 | 0.761*** | -0.842 | 1.232** | 1.186** | 0.396*** | -0.209** | 0.720*** |
| | (0.161) | (0.150) | (0.167) | (0.577) | (0.537) | (0.540) | (0.085) | (0.082) | (0.133) |
| Ext.MA FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes | Yes | Yes | Not applicable | Not applicable | Not applicable |
| Observations | 23,816 | 23,816 | 23,816 | 7,309 | 7,309 | 7,309 | 14,140 | 14,140 | 14,140 |
| Adjusted R2 | 0.130 | 0.086 | 0.200 | 0.102 | 0.045 | 0.111 | 0.192 | 0.129 | 0.212 |

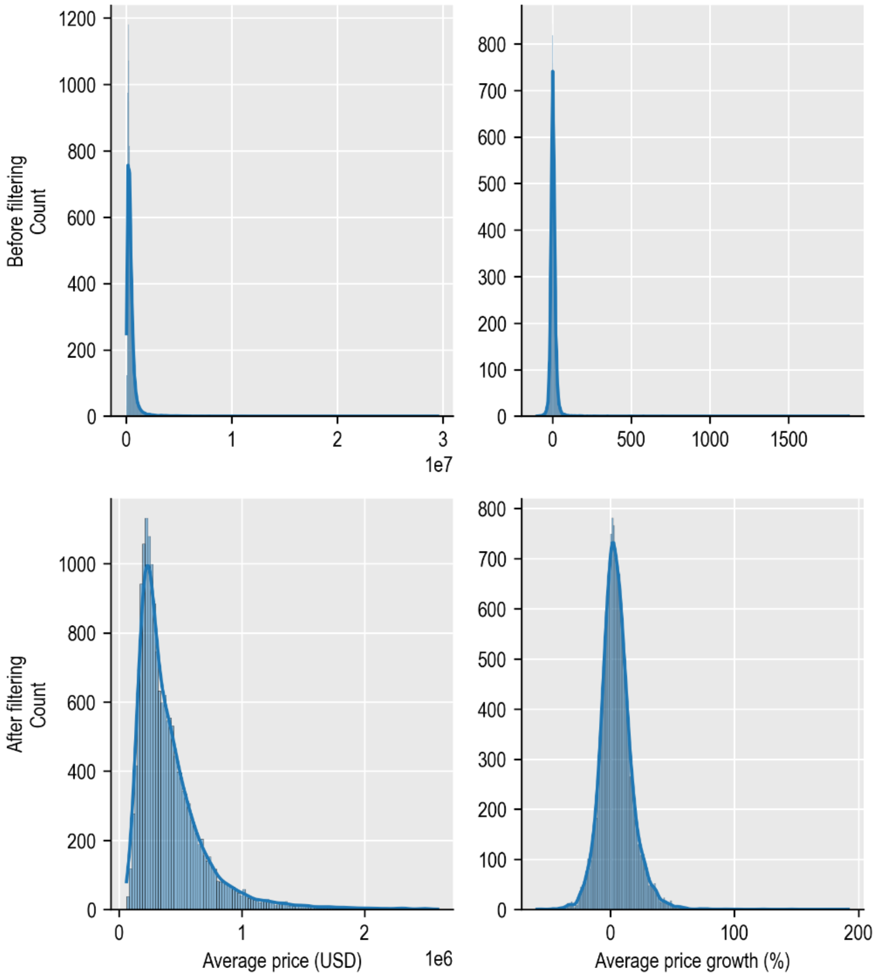
Note: *p<0.1; **p<0.05; ***p<0.01. Robust standard errors.

# Annex D. Data quality and limitations

To cope with data quality issues, the following pre-processing steps were applied on the transactions data:

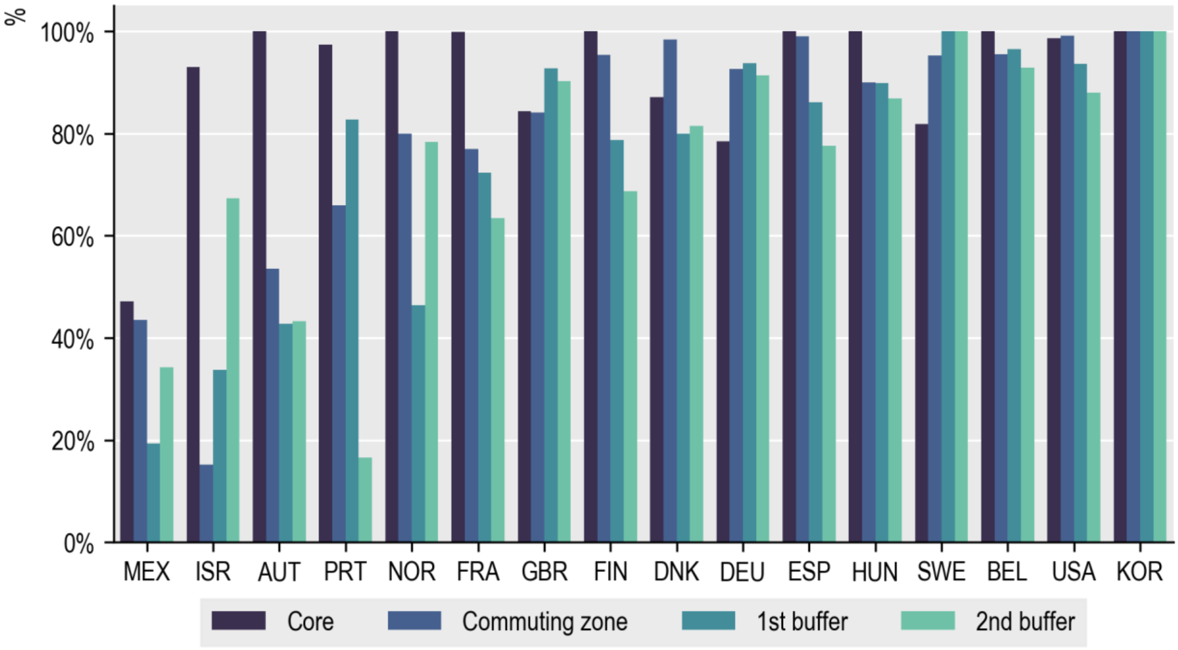
- Transactions within the time frame 2018-Q1 to 2021-Q4 are first selected and then aggregated at the yearly level. The year-on-year price growth is then computed for all time intervals available within this time frame.
- In a few countries, the distributions of house prices or of price growth rates are skewed due to outliers. This is the case of France for the price growth distribution and of the UK for price levels. Let *k* the country index, $h_k$ the average house price, $g_k$ the year-on-year price growth. House price growth rates outside of $[\overline{g_k} - 3\sigma_k, \overline{g_k} + 3\sigma_k]$ and price levels outside of $[\overline{p_k} - 3\sigma_k, \overline{p_k} + 3\sigma_k]$ are considered as outliers and filtered out. Figure D.1 shows the average price level and price growth distribution across SAUs in the UK after and before this filtering step. For the UK, filtering outliers on the price levels also removes the outliers on the price growth distribution.
- In many countries, because of privacy concerns, average prices are not communicated at the SAU level when the number of transactions is too low. To reduce the noise, this study filters average prices that were not computed on at least 10 transactions.
- Geographical units that do not have price data for all timestamps between 2018 and 2021 are then filtered out.

Figure D.1. House prices in the UK, levels (left) and year-on-year growth (right) distributions before (top) and after (bottom) filtering



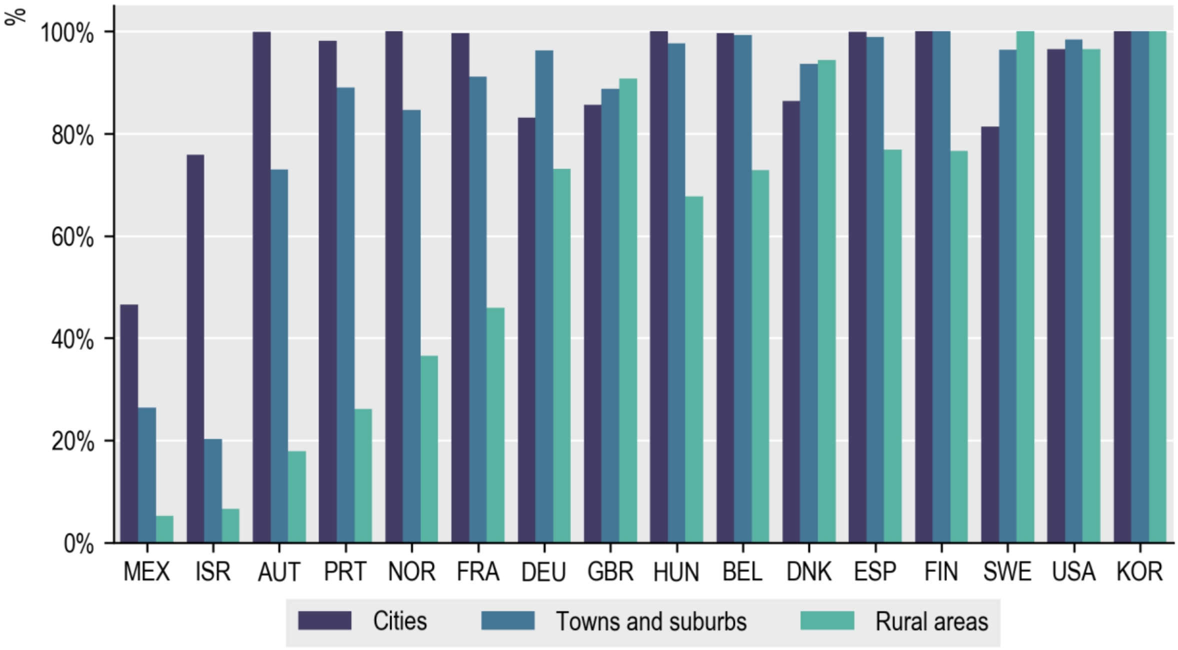
These different processing steps have an impact on the geographical coverage of the database. Figure D.2 shows for each country the data coverage by buffer and Figure D.3 by degree of urbanisation. In 11 countries, the data coverage is high both within and outside the metropolitan boundaries, as well as in the different types of settlements, although in rural areas the coverage is on average lower than in cities towns and suburbs. However, in Mexico, Israel, Portugal and Austria, the data coverage is lower than in other countries and is particularly low in rural areas and in the buffers.

Figure D.2. Share of population covered by metropolitan area ring in the Geography of Housing Demand database



Note: Only geographical units located within large metropolitan areas and their buffers are included.

Figure D.3. Share of population covered by DEGURBA in the Geography of Housing Demand database



Note: Only geographical units located within large metropolitan areas and their buffers are included.