**Measuring land volume and price for estimation of productivity growth in OECD countries**

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**1. Introduction**

This appendix details the estimation of cross-country stocks of land for productivity growth measurement. This requires a price/volume decomposition of land stocks, from which we can estimate the annual growth of land services input and user cost of land. As we are content with getting a measure of input volume and input price *growth*, the constant-price stock of land can be measured up to a normalizing factor. Section 2 shows how Fisher indices are used to decompose land value into price and volume components up to a normalizing factor.

Reasonable land data being hard to come by, getting enough country-wise estimates for a worthwhile cross-country study is a challenge. In its last revision in 2008, the System of National Accounts (SNA) recommends countries to measure both nominal and real land stocks for their annual national accounts (UN, 2009[[1]](#footnote-1)). The incentive for European countries to measure land is even stronger, as they are required to transmit household’s holdings of land to Eurostat since 2017 (Eurostat, 2015). But most OECD statistical agencies still do not include land stocks in their published balance sheet, and those that do only provide a measure of nominal stocks of land. Korea is alone in publishing a price/volume decomposition over multiple decades. Even when national statistical agencies do publish national balance sheet land data, the methods and assumptions behind that data must be carefully assessed. In Section 3, we examine the different methods statistical agencies use to estimate land stocks and determine which ones are adequate for our productivity measurement purpose.

To hope to obtain price and volume land series, we had to complement the sparse balance sheet information with other datasets. We also rely on previous country-specific land measurement studies. We obtain reasonable price/volume estimates for 7 OECD countries: Australia, France, Italy, Japan, Korea, Spain and the United States. The estimation procedures for each country are detailed in Section 4.

Because our goal is to estimate productivity growth for national economies, it would be ideal to sum up the whole stock of land for a country. This means getting price/volume estimates for all types of land (residential, commercial, agricultural, etc.) for all sectors of the economy. This is not always possible, as some land types are less well covered than others.[[2]](#footnote-2) Thus, we try to cover the most land categories possible in each country. Also, to be of use in our project, a country’s land data must cover multiple decades, because (1) we are interested in testing the idea that land price and volume changes explain some of the secular patterns in cross-country productivity growth and (2) measured land stocks exhibit unreasonable volatility from year to year and only make sense when considered over long periods, as is shown in Section 4. Fortunately, we have reasonable land data going back to at least the 1970s for all of the countries above.

**2. Accounting method**

In their attempt to decompose long-run house price inflation into land and structure inflation, Knoll, Schularik and Steger (2017) assume a Cobb-Douglas production function of housing, with land and structure as inputs. That way, under profit-maximization and using observed construction costs as a proxy for the price of structures, imputed land prices can be traced out from the dual of the production function. To avoid assuming a production function and because we use countries’ balance sheet land values rather than only prices, we will not use this method. Instead we rely on index theory to impute land prices and volumes. This restricts us to measuring price growth from a baseline year rather than absolute price level, but that is sufficient for productivity growth measurement purposes. Our method for estimating land price and volume series is similar to that of Davis and Heathcote (2008).

Let the market value of a unit of real estate at the end of period be defined as the sum of the replacement cost of the physical structures and the value of the underlying land ,

|  |  |  |
| --- | --- | --- |
|  |  | (1) |
|  |  |  |

From equation (1), we can safely assume that the period-to-period growth in the price of real estate is the weighted mean of the growth in the replacement cost of structures and the growth in the price of land . Which type of mean and which weights should we use? Davis and Heathcote (2008) use a Laspeyres index to generate a land price index, hence assuming the mean is geometric and the weights are the base-period expenditure shares,

|  |  |  |
| --- | --- | --- |
|  |  | (2) |

Employing a Laspeyres index lead to an overweighting of early-period expenditures. The obvious alternative is the Paasche index, which uses the current-period volumes rather than base-period volumes . Rearranging, the Paasche index becomes the harmonic mean of component price growth weighted by current-period expenditure shares,

|  |  |  |
| --- | --- | --- |
|  |  | (3) |

This on the other hand leads to an overweighting of latter periods. To obtain an index somewhere between the Laspeyres and the Paasche, we instead use a Fisher index, the geometric mean of and , which has been proven to satisfy important properties (Diewert, 1992; Diewert, 1997) and to approximate other alternative index forms (Diewert, 1978),

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| --- | --- | --- |
|  |  | (4) |

In our case, the price index we want to compute is that of land rather than real estate. We can rewrite (1) as,

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| --- | --- | --- |
|  |  | (5) |

By symmetry, can then be obtained by computing the Fisher index of the “components” of land, where the stock of structures is treated as a negative component, i.e.

|  |  |  |
| --- | --- | --- |
|  |  | (6) |

where and .

We prefer a chained index – where the base period updates every period – to a fixed-base index – where for the whole sample. This avoids a large drift between and , and generates a Fisher index that tends to be closer to the “true” index. This is especially true for samples that extend over multiple periods and that exhibit limited price and volume volatility (Diewert, 1978), as is the case with our data.

We also employ chain Fisher indices to aggregate the price and volume indices of subcategories of land (residential, commercial, agricultural, etc.).

**3. Measurement**

A unit of land can be classified according to its use. Table 1 shows the OECD-Eurostat preferred classification of land.

**Table 1: Eurostat-OECD proposed land classification (Eurostat, 2015)**

|  |
| --- |
| Classification of land |
| 1. Land underlying buildings and structures |
| 1.1 Land underlying dwellings |
| 1.2 Land underlying other buildings and structures |
| 1.2.1 Land underlying other buildings |
| 1.2.2 Land underlying structures |
| 2. Land under cultivation |
| 2.1 Agricultural land |
| 2.2 Forestry land |
| 2.3 Surface water used for aquaculture |
| 3. Recreational land and associated surface water |
| 4. Other land and associated surface water |

A unit of land can also be classified according to the ownership of the asset (households, corporation, government, etc.). Ideally, land owned by the government should be excluded from our measured stocks. Indeed, in the 2008 SNA, return on general government land is not included in output, so land services for the general government sector should not be used as an input in productivity measurement.[[3]](#footnote-3)

Categories 1.1, 1.2.1, and 2.1 are the ones we will focus on, as they make up the bulk of nominal land value. For example, for Korea, these three categories add up to 74 % of total measured land value in 2018. Ideally, forestry land (cat. 2.2) should also be measured, but because resource depletion is not recorded as a depreciation item in the SNA (SNA, 2008) – and so does not enter as input or output in our productivity equation – we exclude it. Land underlying structures (cat. 1.2.2) is rarely measured using a reasonable method[[4]](#footnote-4) and is in large part owned by governments (Eurostat, 2015), so we do not include it either. The Eurostat-OECD categories are proposed as a minimum classification. The more granularity we have in our variables, the less measurement error will result from matching structures series with real estate series when performing the decomposition presented in Section 2.

As explained in Section 2, to estimate land price/volume, price/volume series are needed for both structures and total real estate in the categories mentioned above. The least constraining variable in measuring land stocks is structures. Getting estimates of and is straightforward for OECD countries. Most of them publish official balance sheet data on nominal and real stocks of structures, through their national statistical agencies and/or the OECD.Stat website[[5]](#footnote-5). The greatest challenge with structures is matching subcategories of structures to their matching real estate and land stocks. Indeed, in equation (5), subtracting the value of all structures from the value of residential real estate would generate an unreasonably low estimate of the value of land underlying dwellings. Having a precise matching of stocks of structures with stocks of market-value real estate (or nominal land) is one of the biggest hurdles to obtaining sensible land estimates.

For countries that do not publish balance sheet stocks of structures for the complete sample we require, we can retropolate the series using the perpetual inventory method (PIM), which is the OECD’s preferred method for estimating stocks of fixed assets (UN, 2008),

|  |  |  |
| --- | --- | --- |
|  |  | (7) |

where is the net real capital formation during period . This equation implies that the real stock of structures can be linearly added from one period to the other. From nominal and real stocks can be computed the implied replacement cost of structures In practice, we do not need to perform PIM ourselves. Instead, we can rely on data from KLEMS, a productivity measurement initiative (Jäger, 2018). They follow SNA guidelines to compute fixed asset stocks by type of asset whenever a country’s gross capital formation data allows it.

Real estate market value is trickier to obtain, as it must be measured from census, survey, appraisal and/or cadastral data, which are rarely made public in their entirety.[[6]](#footnote-6) Obtaining this type of data is conceivable for residential real estate and agricultural real estate, but often problematic for commercial real estate.

To deflate nominal real estate stocks, we use real estate price indices. In general, OECD countries are covered by at least one national residential price index. Eurostat (2013) compiles the types of residential real estate price indices employed in Section 4. As is the case with the problematic matching of structures series with real estate value series, matching real estate price indices with nominal real estate stocks can be a source of measurement error. Great care is applied to make sure that the price indices cover the same type of real estate as the nominal stock series, but in most cases the fit will be imperfect.

As mentioned in Section 1, some countries measure and publish land stocks on their balance sheet. While we use these estimates when possible, they cannot be taken at face value. The methods and/or data sources employed by some national statistical agencies to estimate land stocks do not lead to sensible estimates. Using those for productivity measurement would lead to excessively biased results. Furthermore, only Korea publishes data on both nominal and real land stocks. Other national statistical agencies exclusively publish nominal stocks, so the accounting method presented in Section 2 is still needed to perform a price/volume decomposition for productivity measurement. We summarize three families of land estimation methods, drawing a line between methods that meet our standards for productivity measurement and those that do not. The methodological explanations below all come from Eurostat (2015). The detailed treatment of each methods can be found in the following sections of Eurostat (2015): 5 for the direct method, 6.2 for the residual method and 6.3 for the land-to-structure method.[[7]](#footnote-7)

The fact that two different countries use the same estimation method does not imply that their estimates are of the same quality. For a given estimation method, the quality of outputted land measures depends on the inputs’ disaggregation level and overall quality. In general, an estimation procedure that starts at a micro level – e.g. individual land plots – will yield more accurate and smoother results than one that starts with more aggregate inputs – e.g. regional aggregates of land value or area. An estimation will also yield higher quality outputs if the inputs are well measured. For example, in the direct method, using infrequently updated public appraisals as a measure of land prices will lead to biased nominal land stocks. In the residual method, using incorrect depreciation rates to accumulate fixed investment in dwellings will lead to bad estimates. These examples will become more relevant once the methods themselves have been outlined.

The **direct method** consists of multiplying the area of each land plot by a price per area that matches the characteristics of the land plot. It can be generalized by the equation

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| --- | --- | --- |
|  |  | (8) |
|  |  |  |

where is the price per area that matches the characteristics of a given land plot at time and is the area of land plot at time .[[8]](#footnote-8) The implementation of the method depends on the level of disaggregation available. If each plot’s value is directly and regularly assessed, for instance by tax officials, a different price series could be applied to each independent plot. The data requirements for such a micro procedure to be applied across a country are strict. If instead is a sum of the area of land in a cross-section of total land – e.g. semi-urban land underlying dwellings in a given county – then it can be multiplied by a that corresponds to this category of land. It is obvious that the more disaggregated the input data, the best the match between area and price series, and the higher the quality of the estimated stocks. The price itself can come from a separate estimation on a representative sample of land – in the form of surveys, appraisals, unbuilt land transactions, hedonic regressions, etc. SNA guidelines for prices are that the preferred price is the one that most closely approximates actual real-time market transaction price.

The direct method is transparent and computationally simple. Also, because the bedrock input of the direct method is land area, it can be used to measure every type of land from Table 1 in the same framework. This allows for coherent comparisons between stocks of different land types. In addition, the Eurostat-OECD guidelines note that the direct method tends to lead to smoother land series compared to indirect approaches. This property comes from the direct method being less sensitive to key assumptions (e.g. perpetual inventory method assumptions when using the indirect method). As noted in Section 1, the price/volume decomposition presented in Section 2 tends to itself produce volatile estimates. Starting from inputs that are smoother contributes to limiting that volatility.

Among the countries with official balance sheet nominal land stocks for which we managed to obtain a reasonable price/volume decomposition, Korea, Japan, Australia and France employ the direct method.[[9]](#footnote-9) Korea starts from the lowest aggregation level: individual land plots are multiplied by their publicly assessed land value adjusted to market value using actual real estate transactions. Japan follows the same procedure, without adjusting publicly appraised land price with market-based information. This could imply that Japanese land value is underestimated. Australia uses the direct method with publicly assessed land price to compute the value of rural land – i.e. agricultural land – and land underlying commercial buildings – a subset of land underlying non-residential buildings.[[10]](#footnote-10) France employs the direct method for agricultural land.

The **residual method** is an alternative method for countries who do not have – or cannot reliably estimate – price and volume information on land that is separate from the structure situated on the land. This is more realistic in many cases, as land and structures are typically sold jointly in a transaction. The residual method instead takes the combined value of real estate (the sum of land and structures) and subtracts from it an estimate of the value of structures. It can be generalized by the equation

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| --- | --- | --- |
|  |  | (9) |

where is the nominal value of the combined land and structures of real estate stock at time and is the nominal value of structures in real estate stock at time . As the RHS of equation 9 is additive (rather than multiplicative as in equation 8), the level of aggregation of does not matter when the objective is to estimate a national estimate of the value of the stock of land. Once a country has estimates of and , it is straightforward to compute , regardless of the aggregation level of . The struggle comes from estimating.

The combined value of real estate can be obtained from either a bottom-up or top-down approach.[[11]](#footnote-11) The bottom-up approach consists in adding up the value of each real estate property in a country. The value of individual property units can come from appraisals, transactions, or can be imputed from the appraisal/transaction value of real estate with similar characteristics. The top-down approach consists in measuring the total number of properties of a certain type in a region and then multiplying it by the average property value for that type in that region. The quantity of properties for the top-down approach can be obtained from censuses, cadastres or surveys, possible complemented by construction statistics to adjust for year-to-year changes, while the average price can be estimated from transactions, appraisals, censuses or surveys. Of course, as was the case in the direct method, the more type/region cross-sections used, the lower the chances of getting biased estimates of combined value. The value of structures is typically estimated by PIM. This is more straightforward than measuring , as the fixed investment data at the foundation of PIM is widely available, given that gross capital formation has been a required component of the SNA since its genesis (UN, 1953).

Estimating nominal land stock value by the residual method is necessary when information on the combined value of real estate, but not on the separate value of the land component, is available. One half of the RHS of equation (9), the PIM estimate of structures stock value, is available going back multiple decades for most OECD countries. On the other hand, uncertainty in assumptions underlying PIM (depreciation, length of service length) make it harder to evaluate the accuracy of land value estimated residually. The quality of estimates also is also highly dependant on the quality of the combined value estimates . When the combined value is computed through census or cadastral data to derive volume and actual transactions to derive price, the residual method yields consistent outputs. But if the area coverage is incomplete and/or the price data is non-representative[[12]](#footnote-12), can be severely biased. In short, the theory behind the residual method is sound, but in practice the approach can lead to unobserved biases.

In our sample of countries, Australia and France publish balance sheet land underlying dwellings value series estimated through the residual method.[[13]](#footnote-13) Australia follows the best practices in terms of estimating land residually. For , the Australian Bureau of Statistics uses census data to measure the number of dwellings stratified by dwellings type and location, which it then matches with dwellings price from transactions of both new and old housing. To estimate , it uses geometric depreciation, the OECD’s recommended depreciation rate (Blades, 1997; Jäger, 2018). France uses census data for both volume *and* price data, since it records the assessed value of individual dwellings in its Housing Census (Baron, 2008)[[14]](#footnote-14). On one hand, this guarantees an accurate between dwelling volume and dwelling price. On the other hand, as explained above, assessed price is less reliable than price derived from actual transactions. Straight-line depreciation is used for . While these are not reasons to entirely dismiss the French land underlying dwellings series, researchers should be aware of the weaknesses in their procedure.

The **land-to-structure ratio (LSR) method** is related to the residual method, in that its two inputs are the combined value of real estate and the value of structures. It can be generalized by the equation

|  |  |  |
| --- | --- | --- |
|  |  | (10) |

where is the land-to-structure ratio of real estate stock at time and, as in equation (9), is the nominal value of structures in at time . As opposed to the residual method, the LSR method described by equation (9) is more accurate the lower the aggregation level it is performed at. Indeed, it is reasonable to suspect that different types of real estate in different regions have different LSRs. At a given location, a single-family house would probably have a high LSR than an apartment building, while a single-family house downtown would probably have a higher LSR than one in the suburbs.

The advantage of the LSR method over the residual method is that it does not require a measure of that covers the entire economy. Instead, estimates of can be computed from subsets of the real estate market for each type/region category , and then applied to economy-wide measures of . The requirements are thus less strict than for the residual method and can allow countries that do not have census or cadastral coverage of their real estate market to estimate land stocks. But for the resulting nominal value of stocks to be accurate, each real estate cross-section must be matched to an appropriate , implying that LSRs must be computed using distinct subsets of the real estate market. For example, if the LSR computed from a subset of urban single-family homes is multiplied with the value of suburban apartment building structures, the resulting land value would likely be significantly undervalued.

Hence, the LSR method can lead to good land stock estimates, but not if applied naively. An illustration of the pitfalls of this method, Canada’s balance sheet land values are estimated using a simplistic version of the LSR method. Statistics Canada derives LSRs from new real estate developments and applies it to aggregate stock of structures estimated through PIM. Because new housing developments are often on the outskirts of urban areas, they tend to have lower land values. Hence, the derived LSRs are too low to be applied across the real estate market. The resulting land values are biased towards zero. Because of that, Canada could not be a part of this study, even though it publishes balance sheet land data going back to the 1970s.

**4. Data**

Each following subsection covers the estimation for a country and starts by discussing the availability (or not) and quality of official balance sheet land stocks. Then follows details of the estimation. Table 2 gives a summary of the countries for which we estimate land data.

The accompanying country-specific Excel files contain all data series referenced below, as well as where to find them. The accompanying Shazam files detail the estimation procedure.

Estimation results are displayed in figures at the end.

**Table 2: Summary of country-wise estimated land data**

|  |  |  |  |
| --- | --- | --- | --- |
| Country | Period covered | Type of land covered | Data sources[[15]](#footnote-15) |
| Australia | 1960-2019 | Land underlying dwellings | ABS (2019a), ABS (2019b), BIS (2019), Coleman (1993), Goldbloom and Craston (2008), Stapledon (2008) |
| France | 1970-2018 | Land underlying dwellings  Agricultural land | Agreste (1984), Baron (2008), BIS (2019), INSEE (2001), INSEE (2019a), INSEE (2019b), Piketty and Zucman (2014), World Bank (2019) |
| Italy | 1965-2017 | Land underlying dwellings | Brandolini et al. (2004), Bank of Italy (2015), Bank of Italy (2019), BIS (2019), OECD (2019f), Pagliano and Rossi (1992), |
| Japan | 1969-2014 | Land underlying dwellings  Agricultural land | CoJ (2000), CoJ (2016), CoJ (2020), OECD (2019a), OECD (2019f) |
| Korea | 1964-2018 | Land underlying dwellings  Land underlying other buildings and structures  Agricultural land | Cho et al. (2016), KOSTAT (2019) |
| Spain | 1970-2013 | Land underlying dwellings  Agricultural land | Artola Blanco et al. (2018), BIS (2019), Jäger (2018), OECD (2019f) |
| United States | 1960-2017 | Land underlying dwellings  Agricultural land | BEA (2019), Davis and Heathcote (2008), USDA (1999), USDA (2014), USDA (2019), USDA (2020) |

**4.1 Australia**

The Australian Bureau of Statistics (ABS) estimates nominal land stocks for four land use categories for 1989-2019: residential, commercial, rural, and other government land (ABS, 2019b). Unfortunately, we end up using only residential land, which corresponds to “land underlying dwellings” in the Eurostat-OECD classification (see Table 1). Land underlying dwellings can be decomposed using the method described in Section 2. In addition, complementary datasets are used to extend the price/volume series back to 1960. The procedure is described below. While it would be ideal to also decompose the commercial and rural land values from ABS, which fit into the land categories this study seeks to estimate, we were not able to so for the following reasons.

Commercial land nominal value is assessed directly through appraisals by state/territory governments (Eurostat, 2015). Decomposing it into price/value components requires stocks of nominal (and real commercial structures. Unfortunately, it is not possible to match ABS land data with net structures stocks. The assessed commercial land covers only a subset of Australia’s non-residential land. As a result, the value of non-residential stocks (ABS, 2019a) is too high when compared to commercial land stocks (ABS, 2019b), which results in unreasonable land price/volume estimates. There is also no possibility to extend the commercial series back to 1960 as we do for residential series. For these two reasons, commercial land is excluded.

The ABS agricultural land data for 1989-2019, estimated by the direct method, can easily be decomposed into price/volume components, as quality agricultural land price and area data exists for that period (World Bank, 2019; ABARES, 2019). Unfortunately, no agricultural land price or value series are available to extend the series back to 1960. To avoid making strong assumptions around the behaviour of agricultural land pre-1989, we exclude agricultural land from our calculations. (Not sure about this, maybe we want to treat it differently (could make assumptions to extend).

All of the data series used in the Australia section are mid-year (June) estimates. We can easily convert it to end-of-year values to match the other countries in this study. But because the other data used for productivity measurement – most of it coming from ABS – is likely to also be in a mid-year format, we keep it as such.[[16]](#footnote-16)

**Land underlying dwellings**

ABS measures land underlying dwellings by estimating the combined value of residential real estate using a “price \* quantity” top-down approach before deriving nominal land value residually. The Australian Census of Population and Housing administered every 5 years is used to estimate the number of residential units for each type and geographical region .[[17]](#footnote-17) The inter-Census years are extrapolated using dwellings completions net of demolitions. The price of a residential unit per type and region is determined through records of transactions from local governments.[[18]](#footnote-18) Then, is computed for each type/region cross-section. From there, the residual method (see Section 3) with PIM-estimated structures is used to get an estimate of the nominal stock of land .

For 1989-2019, the period covered by ABS’s balance sheet land data, it is straightforward to decompose land into price/volume components using the accounting method exposed in Section 2. Series for the nominal (and real ) stock of net dwellings are available from ABS (ABS, 2019a) and a matching housing price index , from BIS (2019). Inputting these series in equations (5) and (6) yields index price and volume series for land underlying dwellings.

To extend this estimation to the period 1960-1989, we use two additional data sources. First, Coleman (1993) uses the same data as ABS to estimate the Australian nominal land stock for the 1984-1991 period. It is unclear why ABS start their series in 1989. We splice the ABS land underlying dwellings series with the Coleman series to extend it back to 1984. Second, the Reserve Bank of Australia (RBA) estimates nominal net housing value going back to 1960 as the product of the number and mean value of dwellings held by the private sector (Goldbloom and Craston, 2008). As the ABS nominal land series covers the national economy and the RBA housing land series covers only the private sector, we should see a discrepancy in the data. As expected, the combined value of the ABS land underlying dwellings value and dwellings value is slightly higher than the RBA housing value. Assuming that the price of government-owned housing follows the same path as that of private housing, we splice the combined ABS series with the RBA series. Having extended the housing stock series back to 1960, all that is needed to decompose land is a price index . The BIS house price index from above covers the 1970-2019. To extend it back to 1960, we splice it with the national housing price series from Stapledon (2008), which is a weighted average of the median house price from the six Australian regional capital cities.[[19]](#footnote-19)

ABS does not publish land series for individual sectors. Their dwellings stock by sector data shows that the government sector owns a negligible share of dwellings (< 0.5 %) for 1989-2019, with no data found for the earlier part of our sample. Hence, we make the assumption that all residential real estate is owned by the private sector.

**4.2 France**

France’s National Institute of Statistics and Economic Studies (INSEE) measures national land for every land use category for the period 1978-2018 (INSEE, 2019a). Unfortunately, as is the case for every country save Korea, INSEE does not publish series for real stocks of land. Thus, we must decompose their estimates of nominal stocks into volume and price components.

For the three land types relevant to this paper, we can only get reasonable estimates for “land underlying dwellings” and “agricultural land”. While these two categories are carefully treated by INSEE as detailed below, the stock of “land underlying other buildings” is computed by valuing the volume of non-residential buildings at the price of residential buildings (Baron, 2008). While this this might be fine for approximative wealth accounting purposes, it does not allow for an accurate price/volume decomposition to compute service flows and user costs. Hence, we will only cover land underlying dwellings and agricultural land. For both of those categories, we manage to extend the data back to 1970, 8 years before the start of the INSEE land data.

**Land underlying dwellings**

Nominal land underlying dwellings owned by households is measured by INSEE for 1978-2018. A Housing Census conducted every three to six years provides a measure of the nominal value of residential real estate for all of France (Baron, 2008). This measure is interpolated for non-Census years using housing starts and a survey-based house price index . In the benchmark year 1988, a national tax appraisal allows INSEE to compute the nominal value of land underlying dwellings using the direct method. The residual from these two stocks is the value of the dwellings stock . From this benchmark year, is extrapolated and retropolated by PIM to obtain a series for . Hence, for non-benchmark years, the difference between and generates a series for .

To decompose the INSEE nominal land underlying dwellings for 1978-2018 into price/volume components, we need measures of the nominal and real stock of structures, and , and a housing price index . Because the INSEE series used only covers residential land owned by households, structures data from the household sector balance sheet are needed. INSEE’s sectoral balance sheets only contain nominal data, so we generate an implicit price index from the national nominal and real dwellings stock and applying it to the nominal household-owned dwellings stock. For , we use the France housing price index from BIS (2019), which covers residences across the entire country.

We now have all the ingredients to decompose land underlying dwellings into price/volume components for 1978-2018. From equation (1), we compute , which is then extended back to 1970 by splicing it with a household-owned residential real estate series from Piketty and Zucman (2014). The BIS housing price for France, which covers the period 1970-2018, can be used to deflate . Fixed assets data – including dwellings – for before 1978 have not been put online by INSEE, but they can be found in older INSEE publications. A measure of for 1970-1978 can be found in the 1995 benchmark balance sheet accounts (INSEE, 2001). Deflating it by INSEE’s dwellings construction cost index (INSEE, 2019b) yields an estimate for . These series are for the entire economy rather than for households only and so do not match perfectly with the land data presented above. Assuming that the growth rate of national dwellings is the same as the growth rate of dwellings owned by housing, we splice the household-owned dwellings series for 1978-2018 with the corresponding national series for 1970-1978.[[20]](#footnote-20)

After performing the decomposition described in equations (5) and (6), we are left with the volume and price of land underlying dwellings owned by households for 1970-1978. To convert this into land underlying dwellings owned by the private sector – i.e. national land minus land owned by government – we use the ownership proportions employed by INSEE to breakdown the stock of housing by sector (Baron, 2008). They assume that the ownership proportions are constant from year to year for 1978-2018; see Table 3.

**Table 3: Share of housing stock ownership by institutional sector (Baron, 2008)**

|  |  |
| --- | --- |
| Institutional sector | Share of housing |
| Households | 82.11 % |
| Non-financial corporations | 14.32 % |
| Financial corporations | 1.65 % |
| Local government | 1.73 % |
| National government | 0.19 % |

**Agricultural land**

Nominal agricultural land is measured by INSEE for 1978-2018 by the direct method using land area and price data from agricultural censuses (Baron, 2008). INSEE publishes nominal land stocks owned by households and non-financial corporations. Since financial corporations own a negligible amount of agricultural land (Baron, 2008), adding these two series together results in a reasonable measure of privately-owned land. To decompose the nominal land value into price and volume components, we use the World Bank’s estimate of agricultural land area in France (World Bank, 2019).[[21]](#footnote-21) It covers the entire national economy, but since we are content in estimating volume and price up to a normalizing factor, dividing INSEE’s estimate of privately-owned nominal land by the World Bank’s volume of national land is reasonable.[[22]](#footnote-22)

To extend the resulting nominal and real estimates of agricultural land to 1970, the implicit price series computed from the 1978-2018 data is spliced with an agricultural land price series for 1970-1978 (Agreste, 1984), which we then multiply by the World Bank land area series, which starts in 1970.

**4.3 Italy**

The Italian National Institute of Statistics (ISTAT) unfortunately does not publish land stocks on its balance sheet. ISTAT has at least tried to estimate land underlying dwellings stocks internally, as they participated in the survey on estimation methods for the compilation of the Eurostat-OECD guide (Eurostat, 2015). There are indications there that they managed to get sensible results, at least for a sample starting in the 2000s.[[23]](#footnote-23) They employ the residual method (see Section 3), similar to our estimation procedure detailed below, which is encouraging. We were not able to find data to estimate other types of land stocks (underlying other buildings, agricultural).

**Land underlying dwellings**

The Bank of Italy’s Survey of Household Income and Wealth Survey (SHIW) is published annually since 2001 (Bank of Italy, 2015; Bank of Italy, 2019). It measures the income and net wealth holdings of Italian households and non-profit institutions serving households.[[24]](#footnote-24) A large component of the measured household wealth is residential real estate, and SHIW measures the value of principal residences, secondary residences, and rented-out residences owned by households. The resulting real estate value series thus covers all residential real estate, except for residences owned by corporations or the government. While the latter is not an issue, as government land stocks are excluded from our analysis (see Section 3), the former is dealt with at the end of the estimation procedure.

Before 2001, the highest quality residential real estate stock series comes from Brandolini et al. (2004). It covers the whole stock of residential real estate owned by households for the years 1965-2002. It is benchmarked to data from the 1991 Census and in the overlapping years (2001-2002) gives estimates of that are 20% than the SHIW estimates. The authors give evidence that the discrepancy is due to underreporting of assets in the SHIW. Hence the Brandolini et al. (2004) series is our preferred series and is extrapolated using the growth rate of the SHIW series for 2002-2017.

As this residential real estate stock series covers every type of residences in the country, it must be deflated by a similarly overarching residential real estate price index to obtain a sensible estimate of residential real estate volume. The Bank of International Settlements publishes the best available index in this respect (BIS, 2019). Their price index for Italy is measured using micro-data from ISTAT and the Bank of Italy and covers all dwellings, old and newly-built, across all of Italy. It results in a reasonably smooth volume series.

For structures, ISTAT publishes balance sheet data for residential structures (“dwellings”) from 1980 to 2017 (ISTAT, 2019). Both nominal () and real () dwellings stocks are available, as needed for the price/volume decomposition of land explained in Section 2.[[25]](#footnote-25) These are net stocks estimated using PIM. The nominal and real series are extended back to 1965 using net dwellings value series from Pagliano and Rossi (1992), who accumulate gross investment in dwellings by PIM. They assume the dwellings depreciation rate for 1965-1979 is identical to the rate in 1980.

To match the dwellings stocks with the real estate stocks, the former must be adjusted to include only dwellings owned by households. Such a series is available for nominal dwellings stocks for 1995-2017 (OECD, 2019f). The stock of dwellings owned by households is then retropolated using the growth rate of the national stock of dwellings. This assumes dwellings owned by households follow the same growth path as national dwellings. This is likely a weak assumption considering that Italian households own about 90% of national dwellings in the period between 1995 and 2017. For real dwellings stocks, for which households-only data is not available, an implicit price is computed for national dwellings () and applied to household-owned nominal stocks to generate a series of real stocks owned by households.

After performing the decomposition discussed in Section 2, we have price and volume measures of land underlying dwellings owned by households. To expand the measure to land underlying dwellings owned by the entire private sector, we increase land volume by 9%, which is the proportion of housing units owned by non-financial corporations in the 1981 and 1991 Censuses (Brandolini et al., 2004) and also corresponds to the ownership of residential structures by non-financial corporations between 1995 and 2017 (ISTAT, 2019).[[26]](#footnote-26)

**4.4 Japan**

Japanese land stocks are estimated through the direct method. Government officials aggregate the publicly assessed values of individual pieces of land to obtain national land stock values. Bodies of land are distinctly identified in cadastral records, while the Ministry of Land, Infrastructure and Transport regularly update their value assessments (Eurostat, 2015; Kim, 2008).[[27]](#footnote-27) Unfortunately, no explanations could be found regarding the procedure used to extrapolate values between official valuations.

The balance sheet land data published by the Cabinet Office of Japan (CoJ) separates land stock values according to land use type (CoJ, 2020; CoJ, 2016; CoJ, 2000). The two series from CoJ that are of interest here are “land underlying buildings and structures” value and “land under cultivation” value. Unfortunately, the former is not further subdivided into “land underlying dwellings” and “land underlying other buildings and structures” as recommended by the Eurostat-OECD guidelines (see Section 3). While this is a hurdle to our estimation, since it is impossible to perform the decomposition from Section 2 with such a coarse land category, we can sidestep the issue with some assumptions. In addition to categorizing land stock value by land use, Japanese National Accounts also separate stocks according to the land ownership. Because structures other than dwellings make up around 1% of the stock of structures owned by households in both nominal and real terms[[28]](#footnote-28), we can interpret the series “land underlying buildings and structures owned by households” as “land underlying dwellings owned by households” with a minimal loss of accuracy. This does not allow us to extract a complementary “land underlying other buildings” series, but this is inconsequential as we would not have had a non-residential real estate price index available to decompose it into price/volume components.

While balance sheet land data for Japan is published for 1960-2018, a price/volume decomposition cannot be performed for the entire sample. First, the double cross-section of land type and land ownership described above reaches back to 1969 in the historical balance sheet (CoJ, 2000). Second, this same cross-section inexplicably stopped being published after the 2014 National Accounts (CoJ, 2016).[[29]](#footnote-29) Hence, the decomposition detailed in the subsections below covers the period 1969-2014.

**Land underlying buildings**

As explained above, the starting point for the decomposition is the balance sheet nominal value of land underlying dwellings owned by households . Thus, it must be matched with nominal () and real () structures stock data covering exclusively dwellings owned by households. The decomposition’s outcomes will be adjusted at the end to account for dwellings owned by corporations.

To get a continuous series for land underlying dwellings owned by households for 1969-2014, we splice the balance sheet series from the 2014 National Accounts, which covers 1994-2014 (CoJ, 2016), with the equivalent series in the 1998 National Accounts, which covers 1969-1998 (CoJ, 2000).

The longest available series for nominal balance sheet dwellings owned by households is published on OECD.Stat and covers 1980-2017 (OECD, 2019f). To extend it back to 1969, we splice it with a series for overall from the 1998 National Accounts (CoJ, 2000), which covers 1969-1998. This assumes that the growth path of dwellings owned by households follows that of overall dwellings. Considering the splice is for a relatively short period (11 years), any drift coming from a shift in ownership patterns of dwellings should be minimal. Unfortunately, the longest series for real balance sheet dwellings owned by households starts in 1994 (OECD, 2019f; CoJ, 2020). Hence the necessary retropolation using overall real dwellings is longer.

The last ingredient to perform the decomposition from Section 2 is a residential price index. We use the index from BIS, which covers residential real estate in all Japanese urban areas (BIS, 2019). Using the OECD housing price index (OECD, 2019a) results in a very similar decomposition.

To adjust the resulting land volume for housing owned by another sector than households, we use dwellings ownership rates. These show that non-financial corporations and government are the two other sectors that own housing in the Japanese national balance sheet. Because government assets our excluded from this study, only dwellings owned by non-financial corporations are relevant.[[30]](#footnote-30) As detailed above, series for dwellings classified by ownership are available only back to 1980 (OECD, 1990c). We assume that the non-financial corporation ownership ratio – between 15 % and 18 % for 1980-2014 – stays constant at its 1980 level (17 %) for 1960-1980, which in practice is what we did when we extended the household-owned dwellings series.

**Agricultural land**

Since the CoJ breaks down land stock series by ownership category, we can directly exclude agricultural land owned by the government. Only privately-owned agricultural land value goes into our computations. As for land underlying dwellings, to get a continuous series for private agricultural land for 1969-2014, we splice the balance sheet series from the 2014 National Accounts, which covers 1994-2014 (CoJ, 2016), with the equivalent series in the 1998 National Accounts, which covers 1969-1998 (CoJ, 2000).

To decompose it into price/volume components, we divide it by Japan’s overall agricultural surface. Because we are estimating volume/price up to a normalizing constant, using a measure of agricultural land surface which includes government-owned land is a minor issue. We use the OECD’s estimate of agricultural surface (OECD, 2019a). The World Bank measure (World Bank, 2019) contains an unexplained kink in 2001, which leads to unreasonable price/volume estimates.

**4.5 Korea**

Statistics Korea (KOSTAT) publish the highest quality official land data of any OECD country. The stock for every type of land is reported on Korea’s balance sheet, subdivided into the recommended Eurostat-OECD categories (see Table 1), in both nominal and real terms (KOSTAT, 2019). KOSTAT also publish a nominal balance sheet for each institutional sector, which will be used to remove government land from the final decomposition.

As explained in Eurostat (2015), the Korean land stock is computed using the direct method; see Section 3 for a summary of the method. The direct method has heavy data requirements, which Korea satisfies with its widespread land registry. Cadastral records document the size of every piece of land and classify it according to land use, while a public real estate price notification system appraises the value of individual land plots annually. Because the appraisals are for tax purposes, they are below the land’s market value. KOSTAT corrects these biased values by collecting the transaction price of every sale of real estate. They adjust the value of non-transacted pieces of land by applying a multiplier computed from similar transacted pieces of land. The value of individual land plots is then aggregated up to the national level.

While the land stock data from KOSTAT is extremely valuable, the series only begin in 1995. To extend the series further back, we rely on the work of researchers at the Bank of Korea who estimated land data from 1964 (Cho et al., 2016). [[31]](#footnote-31) They also employ the direct method, but at a more aggregate level than KOSTAT. Instead of computing the land value for every individual piece of land, they do so at a regional level. They multiply each county’s land area for a given land type by the average land price for that land type in the county. This method is employed to get nominal and real land stocks for 3 benchmark years: 1964, 1976 and 1983, with 1995, the first year of the KOSTAT data, acting as an additional benchmark year. The county-specific stocks in non-benchmark years are computed by interpolating the nominal land value between two benchmark years, linking them with annual rates of price changes from surveys and appraisals.

Unfortunately, the cadastral records used by the Bank of Korea researchers to compute benchmark-year stocks do not make a distinction between land underlying dwellings and land underlying residential buildings. All these are lumped together under the “Building sites” designation. Hence, if we extend back the KOSTAT series with the Cho et al. series, we must aggregate the two categories together. For the sake of comparing land underlying dwellings series for Korea with those for other countries (see Figures 1, 10 and 11), we simply assume that it follows the same pre-1995 growth rate as land underlying buildings. That is of course very unreasonable and is only done for exposition purposes. Table 4 shows how the Cho et al. series are matched to the Statistics Korea ones.

**Table 4: Full sample land categories and their matching categories in KOSTAT (2019) and Cho et al. (2016)**

|  |  |  |
| --- | --- | --- |
| Full sample | KOSTAT (2019) | Cho et al. (2016) |
| Land underlying buildings | Land underlying dwellings  Land underlying other buildings | Building sites  Factory sites (after 1976)[[32]](#footnote-32) |
| Agricultural land | Agricultural land | Dry paddy fields  Paddy fields |

Before splicing the KOSTAT series with the Cho et al. series, we remove government land from both. For the former, the adjustment is straightforward, as a sector-wise balance sheet is available. KOSTAT only publishes their nominal balance sheets by sector, so we must assume that the price path of government land is the same as overall land for both categories. We simply adjust the volume of all types of land by multiplying by the time-varying ratio of nominal private land to nominal national land. For the Cho et al. data, we only have government ownership data for the benchmark years. We linearly interpolate each category’s private ownership ratio between benchmark years.

**Land underlying buildings**

Since it is impossible to keep them in distinct series, we use a Fisher index to aggregate the KOSTAT “Land underlying buildings” and “Land underlying other buildings” series for 1995-2018. We do the same for the Cho et al. “Building sites” and “Factory sites” series for 1964-1995.

**Agricultural land**

For agricultural land we use a fisher index to aggregate the “Dry paddy fields” and “Paddy fields” categories in Cho et al., using the resulting series to splice the KOSTAT price and volume series.

**4.6 Spain**

The Spanish National Institute of Statistics (INE) does not publish balance sheet land stocks. Instead, we rely heavily on research by Artola Blanco et al. (2018).[[33]](#footnote-33) They measure national assets to estimate wealth distribution by sector. Two of the assets they cover – housing and agricultural land – are of great interest here. While their coverage of the national economy is complete and they carefully attribute ownership of assets to different sectors, their objective of measuring wealth distribution is different from ours of measuring productivity growth. Hence, they only measure nominal stocks of dwellings and land , while we also require volume measures to perform a price/volume decomposition of land stocks. Other data sources will thus be exploited to perform this decomposition.

**Land underlying dwellings**

The residential real estate series from Artola Blanco et al. is constructed using data from decadal housing censuses, using transaction- and appraisal-based series to adjust year-to-year values. The census data allows them to divide the ownership of housing between households, corporations and the general government. This allows us to exclude government housing, and thus government land, from our estimates.

The BIS house price index is used to deflate this nominal residential real estate value series (BIS, 2019). It is constructed using micro-data from INE and a price index from the Ministry of Public Works. It covers every type of housing, old and newly-built, across the country. This makes it ideal for deflating the nominal real estate series from Artola Blanco et al. The resulting volume series exhibits some discontinuities, but alternative price indices do not perform better.

Artola Blanco et al. separately compute a series of dwellings (structures) stocks. They use PIM with sector-wise gross capital formation of dwellings to measure net dwellings stocks. Once again, this sectoral decomposition facilitates the exclusion of land owned by the general government from our results. They assume a geometric rate of depreciation, the OECD’s preferred method (Blades, 1997; Jäger, 2018). Furthermore, their dwellings stock data is measured by PIM starting in 1850, which means that the possible bias originating from the choice of starting stock value is likely very small for the 1970-2013 sample. Unfortunately, they only measure nominal stocks of housing. To obtain a measure of dwellings volume, we compute an implicit dwellings deflator using KLEMS nominal and real dwellings stocks for Spain (Jäger, 2018). Dividing the Artola Blanco et al. (2018) nominal series by this implicit deflator results in a smooth volume series.

**Agricultural land**

Artola Blanco et al. (2018) compute an agricultural value series by using semi-regular survey data from the Ministry of Agriculture and linearly interpolating the data for the years in between. This data excludes the value of farm structures, so we can use it as it stands. They use census data to distribute agricultural land across three sectors: households, corporations, and government. Hence, we can easily exclude government land.

To perform a price/volume decomposition of the value of agricultural land, we divide the Artola Blanco et al. (2018) series (after exclusion of government land) by the OECD’s measure of agricultural surface that covers both arable land and permanent crops (OECD, 2019a).

**4.7 United States**

The United States’ Bureau of Economic Analysis (BEA) does not publish balance sheet land stock. We use estimated land data from Davis and Heathcote (2008) to get a price/volume decomposition of residential land and BEA and US Department of Agriculture (USDA) data to get a decomposition for agricultural land. The estimation process explained below is similar to the one in Diewert and Fox (2016), although they attempt to measure land stocks owned by the corporate sector rather than the national (private) stocks.

**Land underlying dwellings**

Davis and Heathcote estimate the nominal stock of residential land by accumulating the net new investment in land, which is a time-varying proportion of the sales price of homes built-for-sale (or the value of construction contracts for owner-built homes). They measure the nominal () and real () net dwellings stocks with PIM, using BEA and Census data. Finally, they use the Conventional Mortgage Home Price Index (CMHPI) from Freddie Mac as a housing price index .[[34]](#footnote-34) They benchmark these series to the aggregate nominal housing stock computed from the 2000 Decennial Census of Housing. With that they have all the ingredients to perform a price/volume decomposition of land.

The Davis and Heathcote dataset is hosted on the American Enterprise Institute website, and updated yearly. [[35]](#footnote-35) The quarterly series which uses the CMHPI to measure housing price growth, as described above, starts in 1975. To extend the series back to 1960, a secondary annual dataset from Davis Heathcote is spliced in. Instead of benchmarking value to the 2000 Census and extrapolating using CMHPI (as well as land and structures) growth, the annual dataset uses decadal Census data to measure house value and imputes annual house price growth from it. For the quarterly series, we take the average of Q4 and Q1 to get the year-end value. The annual series are start-of-year values, so we use a 1-year lag of the series to get year-end values.[[36]](#footnote-36)

Note that Davis and Heathcote perform the above estimation for 1-4-unit dwellings, which represent 70% of the total market value of homes in the US. They then scale up the resulting series, assuming that the other housing categories share the dynamics of the 1-4-unit category. Thus, our residential land series for the US are for the whole national economy.

To remove government land from the final stocks, we use data from BEA Table 5.1. (BEA, 2019) which breaks up nominal dwellings by sector. Assuming government-owned residential housing has the same land-structure ratio and implicit price growth as private residential housing, we apply the ratio of private dwellings ownership to our land volume series. From 1960 to 2018, governments on average owned 2% of US dwellings, so these are relatively harmless assumptions.

**Agricultural land**

The USDA Economic Research Service tallies an annual data series of farm real estate market value. This series is based on the Agricultural Census conducted every five years, as well as annual data from the National Agricultural Statistics Service’s Agricultural Survey. The market value of real estate assets reported in the USDA balance sheet includes farmland and farm buildings (USDA, 2019). Farm buildings must thus be subtracted to get a measure of the stock of agricultural land.

For that, we use data from BEA Table 3.1S (BEA, 2019), which breaks up the PIM replacement value of private structures by industry. After subtracting its series of the nominal stock of farm structures from the USDA’s farm real estate market value series, we are left with the nominal stock of agricultural land in the US. As in Diewert and Fox (2016), we use the USDA’s productivity program’s volume estimate for agricultural land to generate a price/volume decomposition for agricultural land (USDA, 2020). We can thus get an implicit land price by dividing our residual estimate of agricultural land stock by the USDA’s quantity index.

All that would be left is to remove government land from overall land stocks. From its surveys on the ownership of US agricultural land (USDA,1999; USDA, 2014), the USDA reports that virtually all agricultural land in the US is privately owned. The 1999 Agricultural Economics and Land Ownership Survey reports “NA” for public acreage, while the 2014 Tenure, Ownership, and Transition of Agricultural Land Survey does not have a category for public land, instead lumping it in the “Other” category, which makes up less than 1% of total land surface.[[37]](#footnote-37) We can therefore safely treat the agricultural land stock estimated above as a private asset.

**Figures**

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1. All subsequent mentions of the 2008 SNA refer to this document. [↑](#footnote-ref-1)
2. An outline of the possible land types in a national balance sheet is shown in Section 3. [↑](#footnote-ref-2)
3. This is not true for publicly owned corporations that compete with private sector businesses. They are usually excluded from the general government sector and their return on land is included in output. [↑](#footnote-ref-3)
4. See the end of Section 3 for a discussion of these methods. [↑](#footnote-ref-4)
5. https://stats.oecd.org/ [↑](#footnote-ref-5)
6. Chapter 6.1 in Eurostat (2015) details how real estate market value is estimated in OECD countries. [↑](#footnote-ref-6)
7. Chapter 6.4 covers the hedonic method for estimating land stock value. Per Eurostat (2015), no country currently uses the hedonic method to estimate official balance sheet land values, so we do not cover it here. Statistics Denmark has been planning a pilot project to test the method as a way to measure Danish land value. In addition, some recent papers have used the hedonic method to estimate the land value of local real estate markets (Diewert and Shimizu, 2016; Burnett-Isaacs et al., 2016). It is not unrealistic to expect the hedonic method to be applied at a country-scale in the future. [↑](#footnote-ref-7)
8. In this equation, to denote land volume we use the variable instead of as in Section 2. In the direct method, is a pure measure of land area (in km2 for example), while in our accounting equations is a volume index. The argument is the same for having instead of . [↑](#footnote-ref-8)
9. A more complete description of these countries’ estimation procedures is presented in their respective subsections in Section 4. [↑](#footnote-ref-9)
10. As explained in Section 4.1, we end up excluding these two land categories from our Australian land estimation effort. [↑](#footnote-ref-10)
11. As stated above, the residual method is detailed in Section 6.2 of Eurostat (2015). But the related issue of how to obtain the combined value is examined in Section 6.1, while a detailed treatment of the PIM approach to measure is done in Section 6.5. [↑](#footnote-ref-11)
12. Eurostat (2015) mentions that using price data from appraisals or from new housing sales that tend to be on the periphery of urban areas lead to a downward bias in . As implied in equation (9), this would lead to estimates that are too low, even negative in some cases. Denmark’s early attempts to measure land stocks for its balance sheet using the residual method lead to negative values (Kim, 2008). [↑](#footnote-ref-12)
13. Korea also reports using the residual method as a check on its di­rect estimates (Eurostat, 2015), though we could not find any details on this alternative procedure. [↑](#footnote-ref-13)
14. As opposed to the rest of the explanations on land estimation methods in this section, the information for France does not come from Eurostat (2015) as their methods are not covered in the Eurostat-OECD guide. Instead, refer to Section II.B in Baron (2008). [↑](#footnote-ref-14)
15. The full references of the data sources can be found in the “References” section at the end of this document. This table tallies the sources from which are taken data series explicitly employed in estimation. In the text below we refer to additional sources for e.g. methodological guidelines. See each country’s respective subsection for more details. [↑](#footnote-ref-15)
16. Hence, the accompanying Excel files contain mid-year values, as opposed to those of the other covered countries, which follow an end-of-year convention. [↑](#footnote-ref-16)
17. In Section 4 we keep the convention adopted in Section 3, where upper-case letters are used to represent actual price, quantity and value variables used by countries to measure land values. Lower-case letters represent our imputed price and volume variables, which are only accurate up to a normalizing factor. There is no difference between nominal values – e.g. – but we still make the distinction for clarity’s sake. [↑](#footnote-ref-17)
18. Each Australian states and territories has a land‑titles office or valuer general’s office that records the transfer of real estate. Real estate price per type/region is obtained from this transfer data (Eurostat, 2015). [↑](#footnote-ref-18)
19. While this price index does not cover the entire country, it still covers the majority of dwellings in the country, and seems to be the standard historical housing price index, as it used in various recent housing-related studies – e.g. Knoll, Schularik and Steger (2017) and Jorda et al. (2017). [↑](#footnote-ref-19)
20. In addition, the 1970-1978 series are in French francs rather than in euros. Since only their growth rate is important for the splicing procedure, we do not need to explicitly convert them into euros. [↑](#footnote-ref-20)
21. Dividing by the World Bank estimate gives a smoother price index than dividing by the area measure from OECD (2019f). The World Bank series also follows closely the decadal land area observations from Agreste (2019), which is used in the estimation of INSEE’s agricultural land stock series (Baron, 2008). The World Bank series ends in 2016. For 2016-2018, we extrapolate it using the average growth rate of the previous five years. [↑](#footnote-ref-21)
22. This assumes that the price of public land follows the same path as the price of private land. This assumption is a weak one, as public land likely makes up a small share of overall land (Baron, 2008). [↑](#footnote-ref-22)
23. See Chapter 6.3 in Eurostat (2015). [↑](#footnote-ref-23)
24. Henceforth in the Italian section, “households” will refer to “households and non-profit institutions serving households”. [↑](#footnote-ref-24)
25. In its data warehouse website, ISTAT does not seem to concatenate its fixed assets stock series with different benchmarks. Hence there are three series from ISTAT covering our sample (1980-1990,1990-1995,1995-2017). They use different benchmark years, with minor differences in levels. We simply take the most recent series and retropolate it using the growth rates of the previous two. [↑](#footnote-ref-25)
26. The ownership of housing by financial corporations is negligible (Brandolini et al., 2004) [↑](#footnote-ref-26)
27. This description of Japanese estimation methods is only accurate for the land types targeted in this article (land underlying buildings and structures, land under cultivation). Other land types, e.g. recreational land and unbuilt government land, are estimated using different procedures. See Eurostat (2015) and Kim (2008) for details. [↑](#footnote-ref-27)
28. The data for structures by ownership is found in Table III.4 in the Stocks section of the 2018 National Accounts (CoJ, 2020) and in Table 9B of the OECD.Stat database (OECD, 2019f). [↑](#footnote-ref-28)
29. Bauluz (2019) came across the same issue when trying to update the wealth series of Piketty and Zucman (2014) and could not find a replacement for the missing dataset. [↑](#footnote-ref-29)
30. Both the private and public non-financial corporations cagegories from the CoJ balance sheet are include, since public corporations’ output is generally excluded from general government output as explained in Section 3. [↑](#footnote-ref-30)
31. The dataset from Cho et al. (2016) was gracefully provided by email by Taehyoung Cho at the Bank of Korea. [↑](#footnote-ref-31)
32. In the 1976 benchmark year, the cadastres added the “Factory sites” category. This is not helpful to us, as land underlying factories is not a Eurostat-OECD recommended category and is not employed in the Statistics Korea national balance sheet. We aggregate it with the “Building sites” category. [↑](#footnote-ref-32)
33. The data from their paper is conveniently available on the World Inequality Database website. Unfortunately, the data in Artola Blanco et al. (2018) does not extend past 2013 (end-of-year). In an email correspondence with the authors, they mentioned that the paper would likely be published in the coming year, at which time the full dataset up to 2017 would be released. [↑](#footnote-ref-33)
34. Davis and Heathcote have a second quarterly dataset that uses the S&P CoreLogic Case-Shiller House Price Index instead of the CMHPI as . The CMHPI is their preferred series, so we use the related dataset. [↑](#footnote-ref-34)
35. The updated dataset can be found at https://www.aei.org/housing/land-price-indicators/. It was recently moved there from the Lincoln Institute of Land Policy website. [↑](#footnote-ref-35)
36. A given year’s Census ends in April of that year, so we assume its data was collected close to the start-of-year. [↑](#footnote-ref-36)
37. Aside from publicly-owned land, the “Other” category also includes land held by cooperatives, estates and non-profit organizations. [↑](#footnote-ref-37)