

Supplementary Information 1 to “Estimating exposure of residential assets to natural hazards in Europe using open data”

Table S1. Unconditional correlation matrix for candidate variables for the building height prediction model, based on all available data (N = 2,375,058).

Variable	1	2	3	4	5	6	7	8
1 Building footprint area	1.000	0.326	-0.031	-0.029	0.081	0.052	-0.045	-0.176
2 Building height	0.326	1.000	0.267	0.357	0.470	0.435	0.177	-0.186
3 Build-up surfaces per 100 m grid	-0.031	0.267	1.000	0.685	0.484	0.582	0.307	-0.035
4 Soil sealing per 100 m grid	-0.029	0.357	0.685	1.000	0.565	0.731	0.209	-0.182
5 Population per 1 km grid	0.081	0.470	0.484	0.565	1.000	0.756	0.352	-0.271
6 Population per 100 m grid	0.052	0.435	0.582	0.731	0.756	1.000	0.257	-0.233
7 Population in an urban cluster	-0.045	0.177	0.307	0.209	0.352	0.257	1.000	0.443
8 Distance from centre of an urban cluster	-0.176	-0.186	-0.035	-0.182	-0.271	-0.233	0.443	1.000

Table S2. Equations and ranges of validation measures used in the paper.

Measure	Equation	Range
Pearson’s coefficient of determination (R ²)	$r^2 = \left(\frac{\sum_{i=1}^n (x_i - \bar{x}_i)(y_i - \bar{y}_i)}{\sqrt{\sum_{i=1}^n (x_i - \bar{x}_i)^2} \sqrt{\sum_{i=1}^n (y_i - \bar{y}_i)^2}} \right)^2$	[-1,1]
Mean absolute error (MAE)	$I_{MAE} = \frac{\sum_{i=1}^n x_i - y_i }{n}$	[0, ∞]
Mean bias error (MBE)	$I_{MBE} = \frac{\sum_{i=1}^n x_i - y_i}{n}$	[-∞, ∞]
Symmetric mean absolute percentage error (SMAPE)	$I_{SMAPE} = \frac{\sum_{i=1}^n x_i - y_i }{\sum_{i=1}^n x_i + y_i }$	[0,1]
Root mean square error (RMSE)	$I_{RMSE} = \sqrt{\frac{\sum_{i=1}^n (x_i^{obs} - x_i^{sim})^2}{n}}$	[0, ∞]

Symbols: x_i is the i -th observation, y_i is the i -th prediction, n is the sample size.

Table S3. Sources of data for estimating residential building value.

Country	Gross stock of dwellings (current and constant prices)	Total floor space area of dwellings
Austria	Eurostat	2004–2017: annual number of dwellings multiplied by average floor space; 2000–2003; number of dwellings multiplied by average floor space in 2004 (Statistics Austria); 2000–2017 revised upwards by 21.9% to account for unoccupied dwellings as of 2011 census (Eurostat)*
Belgium	Eurostat	Number of dwellings (annual 2000–2017) and households (interpolated from 1991, 2001, 2011, 2014–2017 data) (STATBEL) multiplied by average floor space in 2012 (Eurostat)*
Bulgaria	Perpetual Inventory Method (PIM) using starting stock in 1999 (average GFCF of dwellings per m ² of completed dwellings multiplied by total floor space of dwellings), adding annual GFCF of dwellings (2000–2017) and removing annual apparent retirement of dwellings (value per m ² from the average value of previous year's stock); deflator of GFCF of dwellings deflator until 2000 and deflator 'Construction cost, new residential buildings' used afterwards; data from Eurostat (GFCF and deflator) and BNSI (dwelling stock and construction)	2000–2017: annual time series (BNSI); Number of households (interpolated from 1992, 2001, 2011 and 2015 data by BNSI and Eurostat) multiplied by annual average dwelling floor space (BNSI)*
Cyprus	Eurostat (2017 value extrapolated from 2016 using change in number of dwellings and deflator 'Construction cost, new residential buildings')	Annual number of households multiplied by average floor space in 2012; revised upwards by 42.2% to account for unoccupied dwellings as of 2011 census (Eurostat)*
Czechia	Eurostat	Number of households (interpolated from 2001 and 2005–2017 data) multiplied by average floor space in 2012; revised upwards by 8.8% to account for unoccupied dwellings as of 2011 census (Eurostat)*
Denmark	Eurostat	Annual time series for occupied dwellings (DST); revised upwards by 13.8% to account for unoccupied dwellings as of 2011 census (Eurostat)*
Estonia	Eurostat (2017 value extrapolated from 2016 using change in number of dwellings and deflator 'Construction cost, new residential buildings')	2000–2011: Annual time series of dwelling floor space, 2012–2017: number of dwellings (interpolated from 2011, 2016 and 2017 data) multiplied by average floor space in 2011 (Statistics Estonia); 2000–2017: annual number households multiplied by average floor space of dwelling in 2000–2011, with 2011 average floor space applied to 2012–2017 (Statistics Estonia)*
Finland	Eurostat	Annual number of households multiplied by average floor space by Statistics Finland; revised upwards by 10.7% to account for unoccupied dwellings as of 2011 census (Eurostat)*

France	Eurostat	Annual number of all/principal dwellings multiplied by average floor space interpolated from 1996, 2001, 2006 and 2013 estimates (INSEE)*
Germany	Eurostat	Annual time series (DESTATIS)
Greece	Eurostat (2017 value extrapolated from 2016 using change in number of dwellings and deflator 'Construction cost, new residential buildings')	Number of households (interpolated from 1991, 2001, 2011 and 2015 data by Eurostat/ELSTAT) multiplied by average floor space interpolated from 2001 and 2012 data (Eurostat/Federcasa 2006); revised upwards by 54.1% to account for unoccupied dwellings as of 2011 census (Eurostat)*
Hungary	Eurostat (2017 value extrapolated from 2016 using change in number of dwellings and deflator 'Construction cost, new residential buildings')	Annual number of dwellings (KSH) multiplied by average floor space interpolated from 2001 and 2012 data (Eurostat/Federcasa 2006)
Iceland	PIM (service life: 90 years) based on GFCF of dwellings for 1945-2017 and gross national income for 1911-1944; construction price index from 'Building cost index 1939-2019' (Statistics Iceland)	Annual number of dwellings from Nordic Statistics database (DST) multiplied by average floor space in 2012 (Eurostat)
Ireland	Eurostat (2017 value extrapolated from 2016 using change in number of dwellings and deflator 'Construction cost, new residential buildings')	Number of dwellings/households (interpolated from 1996, 2002, 2006, 2011 and 2016 data by CSO) multiplied by average floor space in 2012 (Eurostat)*
Italy	Eurostat	2001 and 2011 value for occupied dwellings (ISTAT/Federcasa 2006) interpolated and then extrapolated using change in the number of households interpolated from 1991, 2001 and 2009–2017 data (ISTAT); revised upwards by 29.3% to account for unoccupied dwellings as of 2011 census (ISTAT)*
Latvia	2000–2001: Eurostat, 2002–2016 extrapolated by adding annual GFCF of dwellings (Eurostat) to deflated stock of dwellings from preceding year reduced by assumed 0.3%	2010–2017: Annual time series; 2000–2009: extrapolated using change in number of households (CSP); annual number of households multiplied by average floor space in 2007–2017, with 2007 average floor space used for 2000–2006 (CSP)*
Lithuania	Eurostat (2017 value extrapolated from 2016 using change in number of dwellings and deflator 'Construction cost, new residential buildings')	Annual time series (Statistics Lithuania)
Luxembourg	Eurostat	Number of households (interpolated from 1991, 2001 and 2005–2017 data by STATEC/Eurostat) multiplied by average floor space interpolated from 2001 and 2012 data (Eurostat/Federcasa 2006); revised upwards by 6.9% to account for unoccupied dwellings as of 2011 census (Eurostat)*
Malta	PIM (service life: 80 years**) based on GFCF of dwellings for 2000-2017 and deflator 'Construction cost, new residential buildings' (Eurostat), total GFCF for 1970-1999 from PWT 9.1, GDP for 1950-1969 from MPD 2018 1969) and 1921–1949 interpolated from 1921, 1930 and 1938 estimates by Apostolides (2010) and 1950 estimate from MPD 2018	Number of households (2005–2017 from Eurostat, extrapolated with population change for 2000–2004) multiplied by average floor space in 2002 (Federcasa 2006)

Netherlands	Eurostat	2011–2017: annual number of dwellings multiplied by average floor space; 2000–2010: annual number of dwellings multiplied by average floor space in 2011 (CBS)
Norway	PIM (service life: 80 years) based on GFCF of dwellings for 1970–2017 (SSB/Eurostat) and total gross investment for 1921–1969 (Grytten 2004)	Number of households (interpolated from 2000 and 2004–2017 data from SSB) multiplied by average floor space in 2012 (Eurostat)
Poland	PIM using starting stock in 1995 (average GFCF of dwellings per m ² of completed dwellings multiplied by total floor space of dwellings), adding annual GFCF of dwellings (1996–2017) and removing annual apparent retirement of dwellings (value per m ² from the average value of previous year's stock); deflator of GFCF of dwellings deflator until 2000 and deflator 'Construction cost, new residential buildings' used afterwards; data from Eurostat (GFCF and deflator) and GUS (dwelling stock and construction)	Annual time series (GUS)
Portugal	Eurostat (2017 value extrapolated from 2016 using change in number of dwellings and deflator 'Construction cost, new residential buildings')	Number of dwellings (interpolated from 1991 and 2001–2017 data by Statistics Portugal) and households (interpolated from 1991, 2001 and 2005–2017 data by Statistics Portugal/Eurostat) multiplied by average floor space in 2011 (Statistics Portugal)*
Romania	PIM using starting stock in 2000 (average GFCF of dwellings per m ² of completed dwellings multiplied by total floor space of dwellings), adding annual GFCF of dwellings (2001–2017) and removing annual apparent retirement of dwellings (value per m ² from the average value of previous year's stock); deflator 'Construction cost, new residential buildings' used; data from Eurostat (GFCF and deflator) and INSSE (dwelling stock and construction)	Annual time series (INSSE); Number of households (interpolated from 1992, 2002, 2005–2017 data by INSSE/Eurostat) multiplied by annual average floor space of dwellings (INSSE)*
Slovakia	Eurostat	Number of households (interpolated from 2001 and 2005–2017 data by Eurostat) multiplied by average floor space in 2012 data (Eurostat); revised upwards by 7.7% to account for unoccupied dwellings as of 2011 census (Eurostat)*
Slovenia	Eurostat	Annual time series (SiStat) for 2002–2014, extrapolated using change in number of households (interpolated from 1991, 2002, 2005–2017 data by SiStat/Eurostat)
Spain	PIM (service life: 60 years) based on GFCF of dwellings for 1964–2017 (Fundación BBVA e Ivie 2018/Eurostat), total GFCF for 1950–1963 from PWT 9.1 and GDP for 1941–1949 from MPD 2018; deflator from 'Construction cost, new residential buildings' (Eurostat)	Number of households (interpolated from 1991, 2001, 2011, 2013–2017 data by INE) multiplied by average floor space from 2001 and 2012 data (Eurostat/Federcasa 2006); revised upwards by 39.4% to account for unoccupied dwellings as of 2011 census (Eurostat)*
Sweden	PIM (service life: 73 years) based on GFCF of dwellings for 1993–2017 from SCB/Eurostat and	Annual number of dwellings (SCB) multiplied by average floor space in 2012 (Eurostat)

	1928–1992 from Edvinsson (2005); deflator from ‘Construction cost, new residential buildings’ (Eurostat)	
Switzerland	PIM (service life: 50 years) based on GFCF of dwellings for 1995–2017 from BFS/Eurostat, 1990–1994 from OECD, 1981–1986 and 1951–1969 from HSSO; and total investment for 1987–1989 and 1970–1980 from HSSO; deflator from ‘Construction cost, new residential buildings’ (Eurostat)	Number of dwellings (interpolated from 2000 and 2009–2017 data by BFS) and households (interpolated from 2000 and 2011–2017 data by BFS/Eurostat) multiplied by average floor space in 2009–2017 (BFS), with 2009 value used for 2000–2008*
United Kingdom	Eurostat	2017: number of dwellings multiplied by average floor space in 2016; 2004–2016: Annual number of dwellings multiplied by average floor space; 2000–2003: number of dwellings multiplied by average floor space in 2004; Note: average floor space refers only to England and Wales (ONS)

Notes:

* value for all dwellings was used for estimating building value per m², while the value for occupied dwellings/principal dwellings/households was used for estimating contents value per m².

** according to national methodology, service life of dwellings is 85 years, but it was truncated here due to the lack of economic data before year 1921.

GFCF = gross fixed capital formation; GDP = gross domestic product; PIM = Perpetual Inventory Method

PWT 9.1 = Penn World Table 9.1 (Feenstra et al. 2015)

MPD 2018 = Maddison Project Database 2018 (Bolt et al. 2018)

Table S4. A note on methodological differences for Latvia and Poland preventing the use of data on the gross stock of dwellings. Based on Eurostat and OECD (2014) and GUS.

Country	Description
Latvia	Gross stock of dwellings is calculated based on prices of newly constructed buildings rather on the basis of the replacement costs of existing stock, which substantially differs in type and quality. Consequently, this results in overestimation of the stocks. As the basis of calculation made by the statistical office of Latvia is the situation in year 2000, we use the national estimate of gross stock for that year as the basis for computing time series for 2001–2017 using PIM with annual GFCF and assumed annual retirement equaling 0.3% of the stock (Eurostat and OECD 2014).
Poland	Gross stock of dwellings that were built before 1995 is calculated at constant replacement values of September 1994, which results in a very low estimate of the total value of dwellings in Poland. PIM is applied instead using our estimate of the initial stock of dwellings in 1995.

Table S5. Reference to methodologies used for obtaining building stock.

Method	Countries
Building stock taken directly from Eurostat database	Austria, Belgium, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Portugal, Slovakia, Slovenia, United Kingdom
Eq. 3 (PIM)	Iceland, Malta, Norway, Spain, Sweden and Switzerland
Eq. 4 (modified PIM)	Bulgaria, Latvia, Poland, Romania

Table S6. Consumption expenditure categories by COICOP 3-digit codes and durable items included in those categories by COICOP 4-digit codes, with assumption on service life and share of durables in final consumption expenditure COICOP 3-digit categories per country.

COICOP code	COICOP category name	Durable items (COICOP code and name)	Service life (years)
05.1	Furniture and furnishings, carpets and other floor coverings	05.1.1 Furniture and furnishings 05.1.2 Carpets and other floor coverings	17
05.3	Household appliances	05.3.1 Major household appliances whether electric or not	15
05.5	Tools and equipment for house and garden	05.5.1 Major tools and equipment	11
06.1	Medical products, appliances and equipment	06.1.3 Therapeutic appliances and equipment	7
08.2	Telephone and telefax equipment	08.2.0 Telephone and telefax equipment	6
09.1	Audio-visual, photographic and information processing equipment	09.1.1 Equipment for the reception, recording and reproduction of sound and picture 09.1.2 Photographic and cinematographic equipment and optical instruments 09.1.3 Information processing equipment	10
09.2	Other major durables for recreation and culture	09.2.1 Major durables for outdoor recreation 09.2.2 Musical instruments and major durables for indoor recreation	16
12.1	Personal care	12.1.2 Electric appliances for personal care	10
12.3	Personal effects n.e.c.	12.3.1 Jewellery, clocks and watches	45

Notes:

- COICOP = Classification of Individual Consumption by Purpose.
- Final consumption expenditure of households is expenditure incurred by resident households on goods or services that are used for the direct satisfaction of individual needs or wants or the collective needs of members of the community. It includes or excludes many specific types of expenditure, for instance excludes purchases of dwellings, land and valuables. See paragraphs 3.94-3.96 of the European System of Accounts (ESA) 2010 manual (Eurostat 2013).
- Service life should include normal wear and tear, obsolescence and accidental damage which can be insured against. It excludes, among other things, exceptional or catastrophic losses, unforeseen obsolescence and uncompensated seizures. See paragraphs 3.139-3.142 and 6.08-6.13 of the ESA 2010 manual.

Table S7. Assumptions on the share of durables in final consumption expenditure COICOP 3-digit categories per country (based on expenditure surveys listed in Table S5).

Country	Spending on durables as % of total spending per COICOP 3-digit category								
	05.1	05.3	05.5	06.1	08.2	09.1	09.2	12.1	12.3
Austria	99.6	76.9	34.0	45.3	100.0	78.7	96.6	2.2	46.3
Belgium	98.7	74.2	30.2	23.9	100.0	66.4	85.6	2.2	47.0
Bulgaria	99.7	79.3	24.5	3.7	100.0	86.7	90.5	0.7	40.4
Cyprus	99.0	87.4	42.2	11.1	100.0	88.0	91.4	0.2	44.7
Czechia	99.2	78.4	46.9	20.5	100.0	85.6	95.7	2.7	40.9
Denmark	97.5	82.6	30.5	34.5	100.0	77.1	96.5	2.5	59.2
Estonia	99.7	85.8	44.6	11.9	100.0	89.3	93.8	1.0	32.5
Finland	91.9	84.4	36.7	25.5	100.0	81.6	91.7	2.0	51.2
France	98.8	83.9	31.6	37.1	100.0	67.5	93.4	0.7	46.1
Germany	94.0	70.5	45.1	36.7	100.0	77.7	88.5	1.6	65.9
Greece	95.8	84.9	18.6	21.3	100.0	73.1	80.0	1.1	28.1
Hungary	96.9	83.7	27.6	11.6	100.0	89.4	91.7	0.7	31.2
Iceland	91.0	70.8	21.7	30.8	100.0	70.4	87.3	8.8	55.8
Ireland	98.7	59.2	21.8	15.9	*4.6	69.6	88.1	0.9	63.2
Italy	90.5	52.8	16.3	23.4	100.0	64.0	93.4	1.1	55.2
Latvia	96.9	80.4	48.6	7.0	100.0	90.5	88.9	1.0	28.3
Lithuania	99.3	81.7	35.1	6.8	100.0	90.6	91.7	1.1	24.5
Luxembourg	99.6	83.0	30.8	44.2	100.0	81.4	89.0	7.6	63.3
Malta	99.5	73.0	16.3	22.3	100.0	82.5	78.4	0.7	**15.5
Netherlands	97.9	75.9	14.3	50.0	100.0	77.3	79.2	4.5	57.8
Norway	99.4	83.7	8.3	29.1	100.0	83.8	90.1	1.8	55.4
Poland	99.4	80.8	26.2	8.0	100.0	86.8	95.2	1.3	16.4
Portugal	97.3	80.0	20.9	15.5	100.0	78.0	70.3	0.5	48.1
Romania	97.5	72.8	41.7	2.5	100.0	91.4	100.0	0.7	47.6
Slovakia	99.2	79.4	31.6	9.4	100.0	90.7	98.4	1.2	28.6
Slovenia	98.7	85.7	69.0	37.9	100.0	88.3	90.0	1.1	28.0
Spain	96.5	76.8	15.3	36.2	100.0	69.8	82.6	1.9	60.5
Sweden	99.0	83.1	29.5	34.3	100.0	68.5	88.8	2.6	55.7
Switzerland***	[38.1]	[14.2]	[11.9]	[26.5]	[4.4]	[14.2]	[2.6]	[48.5]	[16.5]
	80.7	70.6	19.2	11.1	100.0	86.8	100.0	3.0	61.8
United Kingdom	99.9	74.0	29.5	44.5	100.0	70.2	94.9	2.7	61.3

Notes:

* share in COICOP 2-digit category 08 (Communications),

** share in total spending for COICOP categories 12.3, 12.4, 12.5 and 12.6;

*** upper row is the share of COICOP 3-digit category in respective COICOP 2-digit categories (05, 06, 08, 09, 12).

Table S8. Availability of household final consumption expenditure data by country.

Country	Annual final consumption expenditure data (COICOP 3-digit) – sources by year	Detailed consumption expenditure data (COICOP 4-digit) – available surveys (from Eurostat unless otherwise noted)
Austria	1995-2017: Eurostat; 1976-1994: OECD; 1956-1975: extrapolated using total household consumption expenditure from PWT 9.1	1994, 1999, 2005, 2010, 2015
Belgium	1995-2017: Eurostat; 1956-1994: extrapolated using total household consumption expenditure from PWT 9.1	1988, 1994, 1999, 2005, 2010, 2015
Bulgaria	1995-2017: Eurostat; 1970-1994: extrapolated using total household consumption expenditure from PWT 9.1; 1956-1969: extrapolated using GDP from MPD 2018	2005, 2010, 2015
Cyprus	1995-2017: Eurostat; 1960-1994: extrapolated using total private consumption expenditure from CYSTAT; 1956-1959: extrapolated using total household consumption expenditure from PWT 9.1	2005, 2010, 2015
Czechia	1990-2017: CZSO; 1956-1989: extrapolated using GDP from MPD 2018 (Czechoslovakian GDP before 1970)	2005, 2010, 2015
Denmark	1966-2017: DST; 1956-1965: extrapolated using total household consumption expenditure from PWT 9.1	1994, 1999, 2005, 2010
Estonia	1995-2017: Eurostat; 1990-1994: extrapolated using total household consumption expenditure from PWT 9.1; 1950-1989: extrapolated using GDP from MPD 2018 (Soviet GDP per capita before 1980)	2005, 2010, 2015
Finland	1980-2017: Eurostat; 1956-1979: extrapolated using total private consumption expenditure from Statistics Finland	1994, 1999, 2005, 2010, 2015
France	1975-2017: Eurostat; 1959-1974: OECD; 1956-1958: extrapolated using total household consumption expenditure from PWT 9.1	1988, 1994, 1999, 2005, 2010
Germany	1991-2017: DESTATIS; 1956-1990: extrapolated using total household consumption expenditure from PWT 9.1	1994, 1999, 2010, 2015
Greece	1995-2017: Eurostat; 1956-1994: extrapolated using total household consumption expenditure from PWT 9.1	1988, 1994, 1999, 2005, 2010, 2015
Hungary	1995-2017: Eurostat; 1970-1994: extrapolated using total household consumption expenditure from PWT 9.1; 1950-1969: extrapolated using GDP from MPD 2018	2005, 2010, 2015
Iceland	1990-2017: Statistics Iceland; 1956-1989: extrapolated using total private consumption expenditure (Statistics Iceland)	Not available - average shares for the European Union (15 member states) from 1999, 2005, 2010 surveys used
Ireland	1995-2017: Eurostat; 1956-1994: extrapolated using total household consumption expenditure from PWT 9.1	1994, 1999, 2005, 2010, 2015
Italy	1995-2017: Eurostat; 1992-1994: OECD; 1956-1991: extrapolated using total household consumption expenditure from PWT 9.1	1988, 1994, 1999, 2010, 2015
Latvia	1995-2017: Eurostat; 1990-1994: extrapolated using total household consumption expenditure from PWT 9.1; 1950-1989: extrapolated using GDP from MPD 2018 (Soviet GDP per capita before 1980)	2005, 2010, 2015

Lithuania	1995-2017: Eurostat; 1990-1994: extrapolated using total household consumption expenditure from PWT 9.1; 1950-1989: extrapolated using GDP from MPD 2018 (Soviet GDP per capita before 1980)	2005, 2010, 2015
Luxembourg	1995-2017: Eurostat; 1956-1994: extrapolated using total household consumption expenditure from PWT 9.1	1988, 1994, 1999, 2005, 2010, 2015
Malta	2000-2017: Eurostat; 1970-1999: extrapolated using total household consumption expenditure from PWT 9.1; 1956-1969: extrapolated using GDP from PWT 9.1	2005, 2010, 2015
Netherlands	1995-2017: Eurostat; 1980-1994: OECD; 1956-1979: extrapolated using total household consumption expenditure from PWT 9.1	1988, 1994, 1999, 2005, 2015
Norway	1970-2016: SSB; 1956-1969: extrapolated using total private consumption expenditure from Grytten (2004); 2017 extrapolated	2005, 2010
Poland	1995-2017: Eurostat; 1970-1994: extrapolated using total private consumption expenditure from PWT 9.1; 1956-1969: extrapolated using total consumption expenditure from GUS	2005, 2010, 2015
Portugal	1995-2017: Eurostat; 1956-1994: extrapolated using total household consumption expenditure from PWT 9.1	1988, 1994, 1999, 2005, 2010, 2015
Romania	1995-2017: Eurostat; 1960-1994: extrapolated using total household consumption expenditure from PWT 9.1; 1956-1959: extrapolated using GDP from MPD 2018	2005, 2010, 2015
Slovakia	1995-2017: Eurostat; 1990-1994: extrapolated using total household consumption expenditure from PWT 9.1; 1956-1989: extrapolated using GDP from MPD 2018 (Czechoslovakian GDP before 1970)	2005, 2010, 2015
Slovenia	1995-2017: Eurostat; 1990-1994: extrapolated using total household consumption expenditure from PWT 9.1; 1956-1989: extrapolated using GDP from MPD 2018	2005, 2010, 2015
Spain	1995-2017: Eurostat; 1956-1994: extrapolated using total household consumption expenditure from PWT 9.1	1988, 1994, 1999, 2005, 2010, 2015
Sweden	1980-2016: SCB; 1956-1979: extrapolated using total private consumption expenditure from Edvinsson (2005); 2017 extrapolated	1994, 1999, 2005, 2010, 2015
Switzerland	1995-2017: COICOP 2-digit level data from BFS; 1956-1994: extrapolated using total household consumption expenditure from PWT 9.1	Swiss surveys of 2006-2008, 2009-2011 and 2012-2014 (BFS)
United Kingdom	1985-2017: ONS; 1956-1984: extrapolated using total household consumption expenditure from Blue Book 2018 (ONS)	1988, 1994, 1999, 2005, 2010

Notes:

PWT 9.1 = Penn World Table 9.1 (Feenstra et al. 2015)

MPD 2018 = Maddison Project Database 2018 (Bolt et al. 2018)

Table S9. Validation statistics for the building height prediction model (mean value of the uncertainty distribution), depending on the degree of urbanization at the local administrative unit level (Eurostat’s LAUs). Validated for 2% of data points in cities and towns/suburbs, and all data points in rural areas were used.

Degree of urbanisation	N	R ²	MAE (m)	MBE (m)	SMAPE	RMSE (m)	Observed mean (m)
Cities	44,949	0.35	3.32	0.06	0.17	4.79	9.77
Towns and suburbs	2685	0.15	2.15	0.63	0.14	2.85	7.13
Rural areas	3191	0.24	2.09	0.34	0.16	3.44	6.44

Table S10. Comparison of average results from 10-fold cross-validation.

Method	N	R ²	MAE (m)	MBE (m)	SMAPE	RMSE (m)	Observed mean (m)
Non-parametric BN	23,736	0.35	3.25	0.09	0.17	4.72	9.60
Random Forest	23,736	0.30	3.11	-1.40	0.18	5.26	9.60

Table S11. Alternative exposure estimates for residential buildings per m² in nominal prices, euro.

Country	Huizinga et al. (2017), based on a survey by EC Harris (2010)	Huizinga et al. (2017), based on a survey by Turner & Townsend (2013)	Ozcebe et al. (2014)
	Reference year 2010	Reference year 2010	Reference year 2011
Austria	1485		1155
Belgium	1431		1124
Bulgaria	584		961
Cyprus			939
Czechia	1065		838
Denmark	2082		1260
Estonia			797
Finland	1854		1147
France	1621		1080
Germany	2159	1067	1098
Greece	1108		888
Hungary	750		772
Iceland			1097
Ireland	1696	1228	1142
Italy	1365		993
Latvia	889		759
Lithuania			765
Luxembourg			1820
Malta			844
Netherlands	1015	1253	1159
Norway			1651
Poland	1092	554	766
Portugal	837		855
Romania	816		978
Slovakia	828		808
Slovenia			873
Spain	1099		951
Sweden	1688		1231
Switzerland	2117		1501
United Kingdom	1600	1655	1022

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