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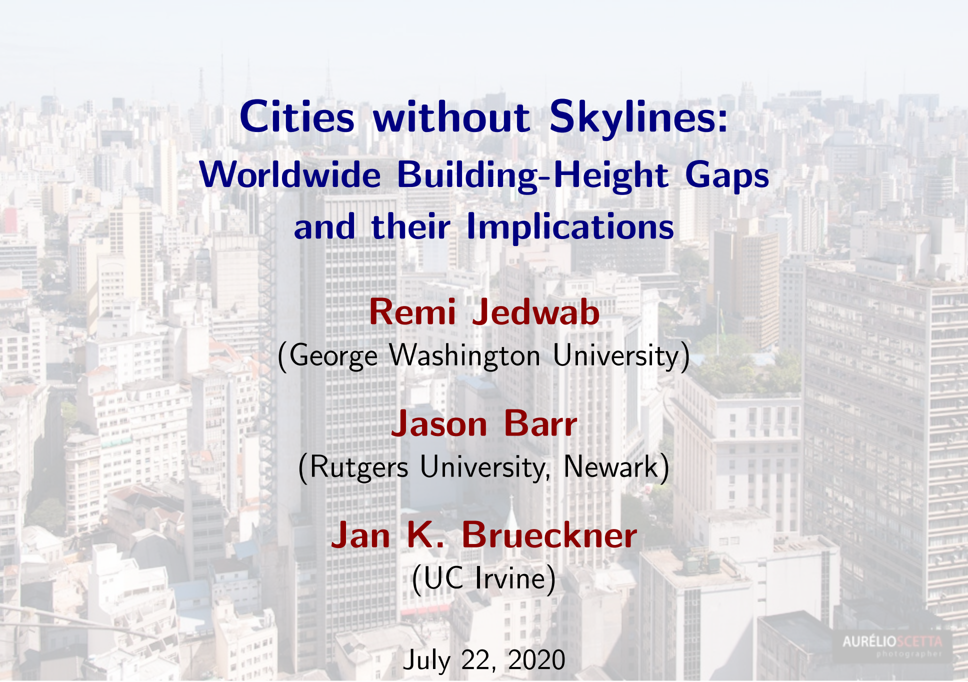

Cities without Skylines:
Worldwide Building-Height Gaps and their Implications

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Motivation: Cities without Skylines

- Land-use regulations constrain urbanization in various ways.
- Building-height restrictions among most visible (DC, Paris, Dublin).
- Goal of paper is to create an indirect measure of the extent of building-height regulation in countries around the world.
- Important since international regulation indexes are scarce.
- Contrasts with U.S. case for which extensive literature.

  Glaeser et al. 2005; Glaeser & Gyourko 2005; Gyourko et al. 2008, 2019

What We Do

- Data set that inventories all the world's *tall buildings* ($\geq$ 80 m): city, year constructed, height, function (e.g., residential).
- For a set of benchmark countries with less stringent regulations, panel regression (1950-2017) relating tall-building stocks to covariates suggested by *standard urban model* (e.g., income).
- Predict building-height gap for tighter regulation countries.

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- Verify gaps correlated with measures of land use regulations.
- Larger gaps for residential rather than for commercial buildings.
- Correlated with housing prices, urban sprawl, air pollution.

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- **Caveats:** First- and second-step regressions are not causal.

Theory

- Standard urban model (Brueckner 1987, Duranton & Puga 2015):

  Building Heights = F(Pop., Income, Land Rent, Commuting Cost)

- Greater demand from larger population → taller buildings.

- Cost of rural-to-urban land conversion → taller buildings.

- Higher income causes urban decentralization BUT countries become more urbanized as get richer → taller buildings.

- Tall buildings long-lived, hence need to control for past stock.

- Any factor that increases value of being centrally located (e.g., agglomeration effects and amenities) reinforces these patterns.

Data: Tall Buildings

Sum of tall building heights for each country-year:

- Data collected by the *Council on Tall Buildings and Urban Habitat* (CTBUH), a not-for-profit group.
- 16,369 tall buildings: ≥ 80 m, about 20 floors (use any available building below 80 m if among top 10 of country).
- Data submitted by CTBUH member network (mostly from construction industry), verified by CTBUH center team.
- Webpage for each building. Data coded by research assistants.
- We know year of construction, height (m), and function.

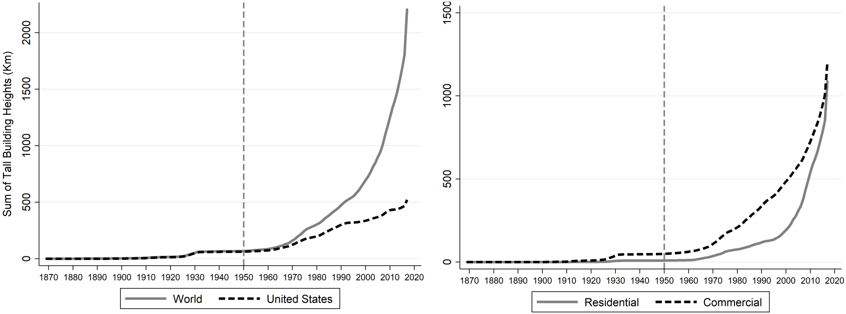
Example from the Tall Buildings Database

Source: See URL: http://www.skyscrapercenter.com/building/burj-khalifa/3

Data: Sample and Other Variables

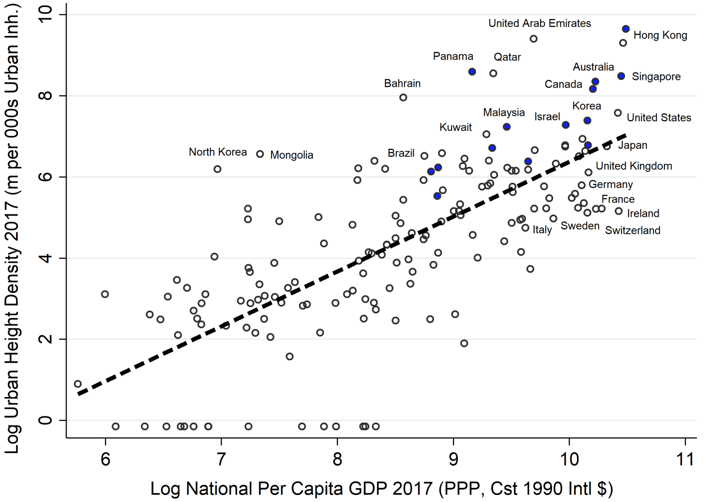
- **Panel regressions** relating tall-building stocks per urban capita to urban per capita income and agricultural land rent.
- **Main sample:** 158 countries in 1950-2017 (which we call 2020)
- **Urban height density:** Sum of building heights ÷ urban pop.
- **Urban per capita income:** Non-agricultural GDP ÷ urban pop.
- **Agricultural land rent:** Ag GDP divided by total land area.
- **Commuting costs:** Urban road data across countries over time since 1950 does not exist. Will ignore in main analysis.

Evolution of Tall-Building Stocks, 1869-2017.



(a) Up until 1950, the U.S. had most of the world's tall buildings. Since then, tall-building stocks in other countries have grown rapidly. The world has added the km equivalent of about 5,000 Empire State Buildings. (b) Most tall buildings commercial until 2000. After 2000, tall residential buildings built at faster pace.

Identification of Benchmark (= Laissez-Faire) Countries.



Regr. log(urb. height density) on log(income) and log(ag.rent) 2017. Benchmark group: residual $\geq$ 75th pctile + upper-middle/high income + democratic (06-17).

Dep. Var.:	Log Urban Height Density (m per 000s Urban Inh.) in Year t ($LUHTDENS_t$)			
	(1)	(2)	(3)	(4)
Countries	All	≥ 0	$\geq$ p75 & DemUMH	$\geq$ p75 & DemH
$LUPCGDP_t$	0.49***	0.68***	1.54**	3.23***
	[0.10]	[0.16]	[0.67]	[0.61]
$LAGRENT_t$	0.13	0.30**	0.55**	0.19
	[0.09]	[0.13]	[0.26]	[0.40]
$LUHTDENS_{t-10}$	0.48***	0.46***	0.46***	0.18
	[0.03]	[0.04]	[0.11]	[0.12]
Cntry FE, Yr FE	Y	Y	Y	Y
Observations	1,106	511	98	56
Countries	158	73	14	8
Adjusted R2	0.79	0.80	0.87	0.91

Notes: Sample of 158 countries x 8 years (1950, 1960, 1970, 1980, 1990, 2000, 2010, 2020) = 1,264 obs. Robust SEs clustered at the country level.

Col. (3)-(4): Benchmark countries only: $\geq$ 75th pctile + democratic + at least upper-middle income (UMH; N = 14) or high income (H; N = 8) today.[1]

[1] H: Australia, Canada, Hong Kong, Israel, Netherlands, South Korea, Uruguay. UM: Brazil, Dom. Rep., Malaysia, N. Macedonia, Panama, Thailand.

	(1) Percentage Change Gap (%, From $UHTDENS_{2020}$))		(2) Per Capita Gap (Km per Mil. Urban Inh.)		(3) Total Gap (Km)	
Rank	Country	Gap	Country	Gap	Country	Gap
1	Ireland	488	Ireland	21	United States	1468
2	Mauritius	451	Mauritius	20	Taiwan	219
3	Slovenia	369	Austria	12	Japan	174
4	Switzerland	361	Taiwan	12	United Kingdom	172
5	Uzbekistan	337	Sri Lanka	8	Germany	168
6	Norway	321	Trinidad	6	China	157
7	Austria	290	Switzerland	6	South Korea	147
8	Taiwan	278	United States	6	France	127
9	Sweden	277	Slovenia	5	Italy	82
10	Sri Lanka	261	Norway	4	Ireland	63
11	Italy	253	South Korea	4	Austria	61
12	Denmark	252	United Kingdom	3	Netherlands	46
13	Trinidad	250	Netherlands	3	Switzerland	35
14	France	249	Estonia	3	Sri Lanka	32
15	Germany	247	Germany	3	Sweden	22
16	Eq. Guinea	243	Sweden	3	Spain	22
17	Finland	223	France	2	Norway	18
18	United Kingdom	215	Denmark	2	India	17
19	Lesotho	212	Italy	2	Belgium	15
20	Portugal	202	Slovakia	2	Poland	12

(i) World should have 2x more km of tall buildings (= 6,000 Empire State Buildings) (ii) Gaps larger for richer countries in 1950 or growing fast since. (iii) U.S. gap from California (state-level analysis; same methodology). (iv) Gaps smaller for commercial buildings. Cities more open to creating jobs than receiving residents.

Do the gaps make sense? Cities in countries with gaps > 0 (= gaps):

Paris

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Vienna

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Dublin

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Do the gaps make sense? Cities in countries with gaps < 0 ($=$ excess):

Panama City

Sao Paulo

Kuala Lumpur

Building-Height Gaps and Land-Use Regulations

- U.S. state-level analysis: Gaps strongly correlate in the expected directions with well-known measures (Saiz, Wharton, Saks).
- For the world, building-height gaps strongly correlate with:
  - Solly Angel's land-use regulation data (200 world cities):

    Gaps correlated with max FAR, not other land-use regulations

    Countries do not "compensate" their residents by having more lenient regulations in other dimensions: greenbelt, UGB, zoning
  - Housing supply responsiveness (Caldera and Johansson 2013)
  - Landlord-friendliness (Global Property Guide)

Source: Intl Comparison Program 2011			Log Total	Log PM
Dep. Var.:	Price Level (100)		Urban Land	10
	Hous	Transp	Area 2011	2017
	(1)	(2)	(3)	(4)
1. Gap UMH	3.32***	-0.67	0.22***	0.08***
	[1.19]	[1.30]	[0.04]	[0.02]
2. Gap H	3.99***	-1.50	0.19***	0.07**
	[1.33]	[1.34]	[0.03]	[0.03]
Observations	147	147	125	156
Ctrls, Wgts	Y	Y	Y	Y

Conditional on income level, cross-sectional correlations with: (i) housing prices (residents not compensated by lower transport costs); (ii) land expansion; (iii) air pollution (due to land expansion). Also: (iv) similar with panel of 12,000 world cities in 1975-2015; (v) gaps in central areas not compensated by peripheral areas.

Robustness Checks: Investigation of Causality

- **Gaps misestimated if coeffs of income and ag rent biased:**
  - Continent-year FE or WB region-year FE
  - Country-specific linear or non-linear trends
  - No effects of the leads
  - Controls for commuting costs: (i) Subways (Gonzalez-Navarro and Turner, 2017; Gendron-Carrier, Gonzalez-Navarro & Turner, 2020) and (ii) National road stocks (no data on urban).
  - Simulations suggest coefficients would need to be much lower to significantly alter the ranking of countries in terms of the gaps.
  - **Caveats:** First- and second-step regressions are not causal.

Robustness Checks: Sampling and Measurement Error

- **Selection of benchmark (= laissez-faire) countries:**
  - Correlation btw residuals used to select countries and Google results for name of the country & cities & skyscrapers = 0.61. Language FE and ctrl for number of famous architects: 0.90.
  - Re-add U.S. to benchmark set.
- **Measurement error (ME) in building heights:**
  - Our data mostly capture 80m+ buildings.
  - Classical ME in dependent variables only affect precision
  - Correlation btw our data and Emporis for 100 cities = 0.79-0.9.
  - Focus on tallest: 100m+, 125m+, etc. where ME less likely.
  - Correlation btw building construction and cement use (main material for 3/4 of buildings) = 0.77 (N = 870 country-years)

Were Results Causal, Welfare Implications?

- **Contribution to global house price boom:**
  - Historical house price data from Knoll, Schularick, and Steger (2017). Gaps possibly account for 22% of rise since 1960.
- **Welfare loss from higher housing and commuting costs:**
  - Bertaud & Brueckner (2005): Welfare loss for each urban resident = commuting cost for the edge resident.
  - Worldwide welfare loss: 1% of global urban income.
- **Welfare loss from air pollution:**
  - Worldwide welfare loss: 0.6-0.8% of global urban income.
- **Welfare loss from spatial misallocation:**
  - Combining Hsieh & Moretti (2019) and our own state-level corr. with Saiz (2010), worldwide loss of 16%.
  - Implausibly high? Caveat: We apply their U.S. estimates to the world.

Dependent Variable:	H-Based ... Building-Height Gap 2020				
	(1)	(2)	(3)	(4)	(5)
LPCGDP 1950	1.63***	1.48	-30.98*	1.08***	19.29
	[0.18]	[1.18]	[15.75]	[0.22]	[20.93]
ΔLPCGDP 1950-2020	2.73***	1.81*	-35.86*	2.52***	16.47
	[0.18]	[0.96]	[20.16]	[0.23]	[24.53]
Home Ownership Share (HO)		-0.03			0.01
		[0.12]			[0.09]
HO*LPCGDP 1950		0.00			0.00
		[0.02]			[0.01]
HO*ΔLPCGDP 19502020		0.01			-0.00
		[0.01]			[0.01]
Log Urb. Planners pc (LUPpc)			-46.03**		27.12
			[22.60]		[30.47]
LUPpc*LPCGDP 1950			4.68**		-2.68
			[2.28]		[3.01]
LUPpc*ΔLPCGDP 19502020			5.57*		-2.08
			[2.91]		[3.54]
Log World Heritage Sites pc (LWHSpc)				-20.80***	-21.04***
				[7.78]	[7.20]
LWHSpc*LPCGDP 1950				2.50***	2.64***
				[0.87]	[0.77]
LWHSpc*ΔLPCGDP 19502020				1.39	0.98
				[1.01]	[0.94]
Observations	158	105	158	158	105
Adjusted R-squared	0.66	0.64	0.68	0.69	0.69

Conditional on income level, gaps are: (i) not correlated with home ownership share, unlike homevoter hypothesis; (ii) higher for richer countries with more renown urban planners per cap.; and (iii) higher for richer countries with more cultural World Heritage Sites per cap. (e.g., historic centres of Florence, Rome & Venice).

THE END

THANK YOU!

Dep. Var.:	Col. (1)-(4): Gap Based on UMH Set				Col. (5)-(8): Gap Based on H Set			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Max FAR	-0.20**	-0.20**	-0.32***	-0.37***	-0.12**	-0.15**	-0.24***	-0.32***
	[0.013]	[0.014]	[0.002]	[0.002]	[0.037]	[0.016]	[0.002]	[0.000]
Urban Containment		0.98		0.42		-0.29		-0.55
		[0.344]		[0.752]		[0.802]		[0.647]
Via Green Belt		-0.87		-1.47		-1.35		-1.36
		[0.584]		[0.418]		[0.401]		[0.408]
Via Urban Growth Boundary		-1.61		-1.05		-0.65		-0.45
		[0.101]		[0.352]		[0.452]		[0.635]
Full or Partial Zoning		1.37		0.68		2.44***		1.22
		[0.205]		[0.428]		[0.002]		[0.200]
Gvt Land Acquisition		0.53		-0.94		0.64		-1.40
		[0.685]		[0.370]		[0.624]		[0.147]
Min Plot Size Y/N			-1.96	-2.06			-1.50	-1.87
			[0.111]	[0.153]			[0.285]	[0.279]
Mths Permit Subdivid.			-0.04	0.04			-0.02	0.07
			[0.446]	[0.552]			[0.636]	[0.302]
Mths Permit Build.			0.12	0.15			0.11	0.16**
			[0.218]	[0.165]			[0.118]	[0.044]
Street Layout Gvt/Mixed			1.70	1.59*			1.13	1.10
			[0.113]	[0.095]			[0.252]	[0.160]
Infrastructure Gvt/Mixed			-1.20	-0.45			-2.17**	-1.21
			[0.241]	[0.717]			[0.050]	[0.264]
Obs./Countries	49	49	47	47	49	49	47	47
R-squared	0.08	0.18	0.30	0.41	0.03	0.14	0.28	0.43

Gaps correlated with max FAR, not other land-use regulations: greenbelt, UGB...

Dep. Var.:	Gap (Log Urban Height Density (m per 000s Urban Inh.) in Year t ($LUHTDENS_t$))							
	(1)	(2)	(3)	(4)	(5)	(6)		(7)
Check:	Baseline	Continent -Year FE	Region -Year FE	Country Trend	Country Trend Sq.	Effects of the Vars t	Leads t+10	Ctrls for Commut.
	Panel A: UMH Set (98 Observations; 14 Countries)							
$LUPCGDP_t$	1.54**	1.97**	1.95**	3.32**	3.91*	2.35***	-0.59	1.83*
	[0.67]	[0.82]	[0.75]	[1.32]	[2.06]	[0.65]	[0.83]	[0.88]
$LAGRENT_t$	0.55**	0.63**	0.59*	-0.05	-0.05	0.44	0.31	0.55**
	[0.26]	[0.29]	[0.31]	[0.61]	[0.76]	[0.78]	[0.74]	[0.22]
	Panel B: H Set (56 Observations; 8 Countries)							
$LUPCGDP_t$	3.23***	3.00***	3.28***	6.06**	6.91*	4.96**	-1.43	4.07***
	[0.61]	[0.47]	[0.49]	[2.13]	[2.99]	[1.99]	[0.68]	[0.40]
$LAGRENT_t$	0.19	-0.07	-0.25	-0.45	-0.41	0.08	0.28	0.18
	[0.40]	[0.48]	[0.85]	[0.59]	[0.80]	[0.68]	[0.71]	[0.31]
Cntry FE, Yr FE	Y	Y	Y	Y	Y	Y	Y	Y
$LUHTDENS_{t-10}$	Y	Y	Y	Y	Y	Y	Y	Y

Gaps misestimated if coeffs biased. Results hold: (i) area-year FE; (ii) country trends; (iii) no effect of leads; (iv) ctrls commuting costs (subways, road stocks country). Simulations suggest coeffs would need to be much lower to alter rankings.