Prospects of Substituting Local Land Finance Revenue with Property Tax in China

Senior Project Report
Computer Science and Economics, Yale College

By Lawrence Wang
Advised by Professor Zeren Li

May 4, 2023

Abstract

Despite decades of deliberation, residential property tax is yet to be levied at a national scale in China. Historically, despite being the primary beneficiary of the tax's revenue, local governments were apathetic toward adoption because it contradicts their existing revenue generation model through land finance, or the sale of land-use rights to property developers. Recently, however, as the property market enters a persistent downturn, the credibility of land finance as a driver of revenue is in question. Furthermore, the central government has been signaling that collection of residential property tax might be imminent.

This project provides timely analysis on the viability of property tax as a substitute revenue generation method for local governments in place of land finance. Using recent data scraped from Fang.com, the leading real estate marketplace in China, for one municipal district and computation done in R and Python, I establish that property tax seems to be a potential alternative. However, upon further analysis completed through the website visualizer and calculator built with the Google Maps API, I find that such a substitution would come at the high price tag of around 20 percent of the disposable income of local residents.

Such a result explains the local government apathy toward the tax, both in the past and now that the property market has entered a persistent slump. The revenue from property tax would both require time to cultivate (and not as immediate as the existing, albeit weakened, land finance revenue) and would be politically difficult to collect due to potential public opposition. Thus, it is reasonable for local governments to avoid this reform. The result of this project can be viewed interactively through the website (https://csec.rence.la/).

Background

Property tax has long been deliberated in China as a method to improve local government finances. The adoption of a residential property tax, however, has stalled for the past decades. Theoretically, the tax would be beneficial for local governments: it brings in much-needed revenue. Chinese local governments have outsized expenditure obligations compared to their revenue generation ability, as the central government reserves the majority of the most profitable taxes while the bulk of the public services are paid for at the local level.[1]

The central government established two pilot sites in Shanghai and Chongqing in 2011.[2] But the programs were met with little enthusiasm from the local level: the two municipal governments stopped mentioning the pilot programs in their government work reports after 2013, indicating both political apathy and lack of progress. These pilots started with low rates, broad exemptions, and exclusion of historic purchases — thus produced little revenue and insignificant socioeconomic results.

Table 1. Overview of the Chongqing and Shanghai Pilot Programs

	Chongqing Program	Shanghai Program
Tax Base	● Single family homes ● Newly purchased luxury properties* ● Newly purchased second or beyond properties for non-locals**	Newly purchased *first* (for non-residents) and *second or beyond* (for Shanghai residents) properties
Tax Rate	Take price to 2-year average: ● 0.5% if less than 3 times ● 1.0% if 3 to 4 times ● 1.2% if more than 4 times	Take price to yearly-average: ● 0.4% if less than 2 times ● 0.6% otherwise
Tax Rules	100m^2 exemption per resident family; Flat 0.5% rate if purchased by non-local; Assessed at transaction price	60m^2 exemption per resident; Assessed at 70% of transaction price

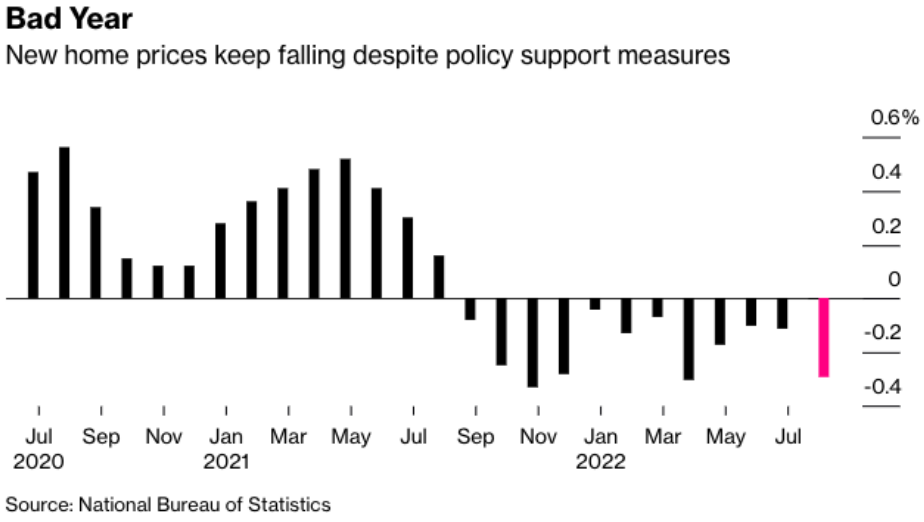
**Luxury: unit price greater than 2 times the two-year average of newly constructed properties*
***Non-locals: migrants who are neither employed locally nor local residents*

One reason behind the slow progress toward adoption is that the property tax is incompatible with the local governments' existing revenue generation model. With acquiescence from the central government, local governments have historically turned to land finance revenue, obtained via the sale of land-use rights to property developers, to address their budgetary

[1] Chunli Shen, Jing Jin, and Heng-fu Zou, "Fiscal Decentralization in China: History, Impact, Challenges and Next Steps," *Annals of Economics and Finance* 13, no. 1 (2012): 1–51, https://ideas.repec.org/a/cuf/journl/y2012v13i1n1.html.
[2] Zaichao Du and Lin Zhang, "Home-Purchase Restriction, Property Tax and Housing Price in China: A Counterfactual Analysis," *Journal of Econometrics* 188, no. 2 (October 2015): 558–68, https://doi.org/10.1016/j.jeconom.2015.03.018.

shortfalls. As land finance revenue is closely tied to land prices, local governments are disincentivized to seek property tax adoption, which might potentially reduce property demand, property prices, and land prices.

Figure 1. Property Market Downturn in China Since 2021.



However, since 2022, the Chinese property market has entered a persistent, nationwide downturn after central government macroprudential measures aimed at limiting property developer leverage. This slump raises questions about the viability of land finance as a local revenue driver. Land finance revenue fell by over 23 percent between 2021 and 2022, a trend that will become increasingly ominous should the pattern of low demand and excessive supply persist. Feeling the squeeze from declining land finance revenue and high local expenditure

during the pandemic, the revenue generation ability of property tax might make the tax more attractive to local governments, thus creating a new opportunity for residential property tax adoption.

Goals

This project aims to understand whether such an opportunity exists. In other words, can property tax revenue substitute for local government land finance revenue of the past? If so, at what tax rate and with what kinds of rules? As such, the goals that the project attempts to accomplish are:

1. Determine whether property tax has the potential to replace land finance revenue.
2. Understand the ideal tax rate design.
3. Make a visualizable property tax calculator as a website.

Overall, the results from the property tax collection simulation in a municipal district, with 777 communities and 508,441 properties indicates that property tax indeed has the potential to replace historic land finance revenue in a quintile-tiered progressive regime with 30 square meters of average exemption. However, it should be noted that this result is limited by the choice of location and the drawback of consuming 20 percent of residents' disposable income.

Methods and Data

To understand the revenue generation ability of a property tax and its potential effects, I chose to conduct a simulation of property tax collection in a locality. This was completed in three steps. First step is to obtain the residential properties data as the tax base. Second step is to apply various predetermined tax regimes to the tax base using R. Third step is to build a web-based visualizer of the data that allows interactive tax rate-setting and revenue projection.

This simulation focuses on the Wuchang district in Wuhan city, the provincial capital of Hubei and largest city in Central China. The choice of location is primarily based on the ease of obtaining data. Zooming in on one district limits the complexity of data extraction, cleaning, and imputation for this one-semester project. Nevertheless, the methods are extendable to other districts and cities in China for a more comprehensive understanding of property tax collection prospects.

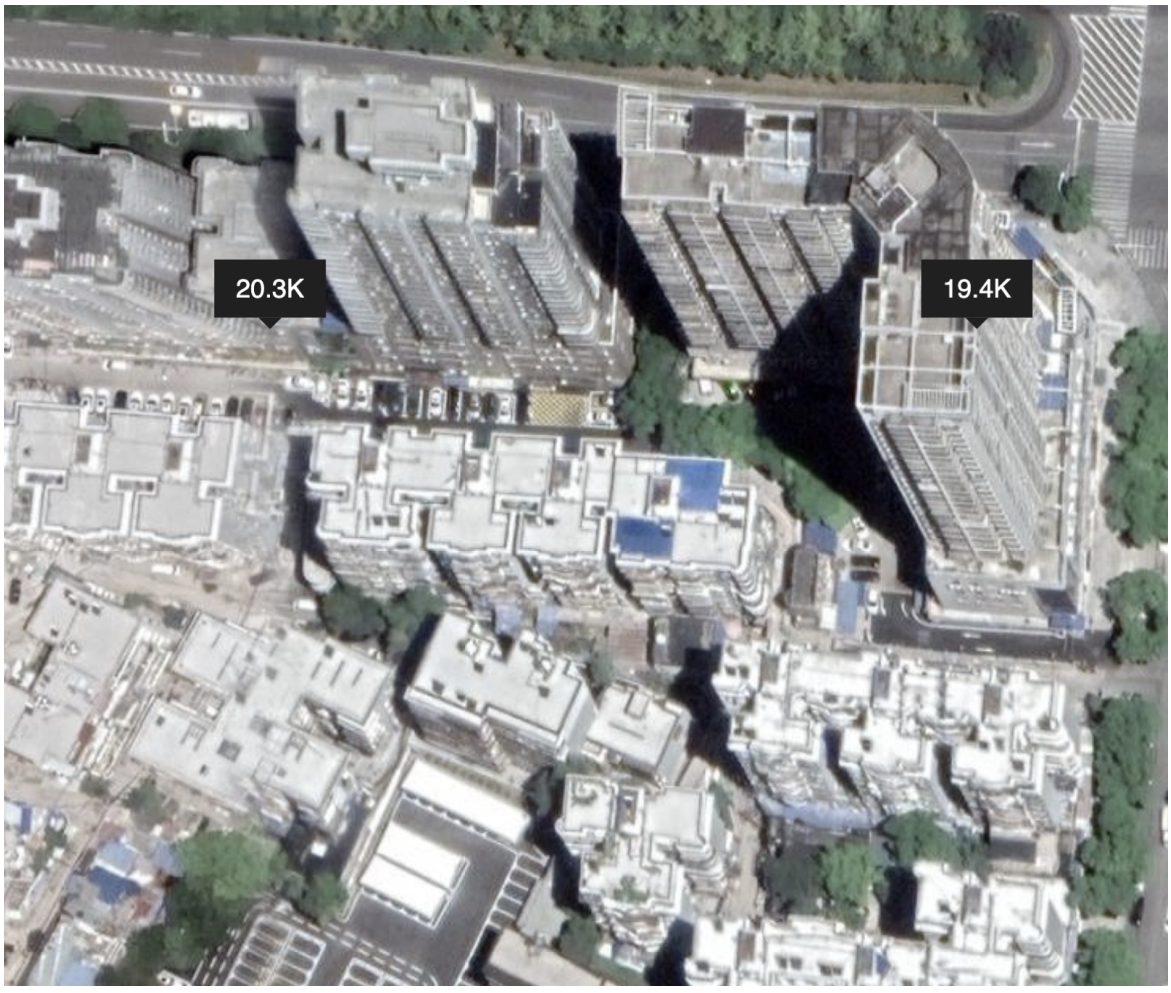
Step 1: Data Procurement

As there is no publicly available centralized database of all residential properties in China, I had to procure the data on my own. To do so, I scraped the leading property marketplace in China, Fang.com, for the list of communities and the number of units in each community. I

leveraged Scrapy, a Python-based web-crawling framework, to extract the community level data. Scrapy is useful for this project as it automates the crawling process and integrates Selenium, which is important because Fang.com requires login credentials to see the full listings, and Selenium automates the login process with Webdrivers.

Fang.com provides data on a per listing basis, as in only the current listings are viewable, as opposed to on a per unit basis that Zillow uses to provide estimated price and transaction history of every unit, on-market and off-market alike. As a result, the data is organized at the community level, with communities being either a stand-alone apartment building, a cluster of single-family homes, a cluster of apartment buildings, or a group of clusters that are developed in series. I used the average price of current listings within a community to extrapolate the community-wide average price. For communities that do not have any current listings, the average price is imputed using the average price of nearby communities. For communities that are not included on Fang.com or are missing the number of units, that number is imputed based on the aerial image of the community.

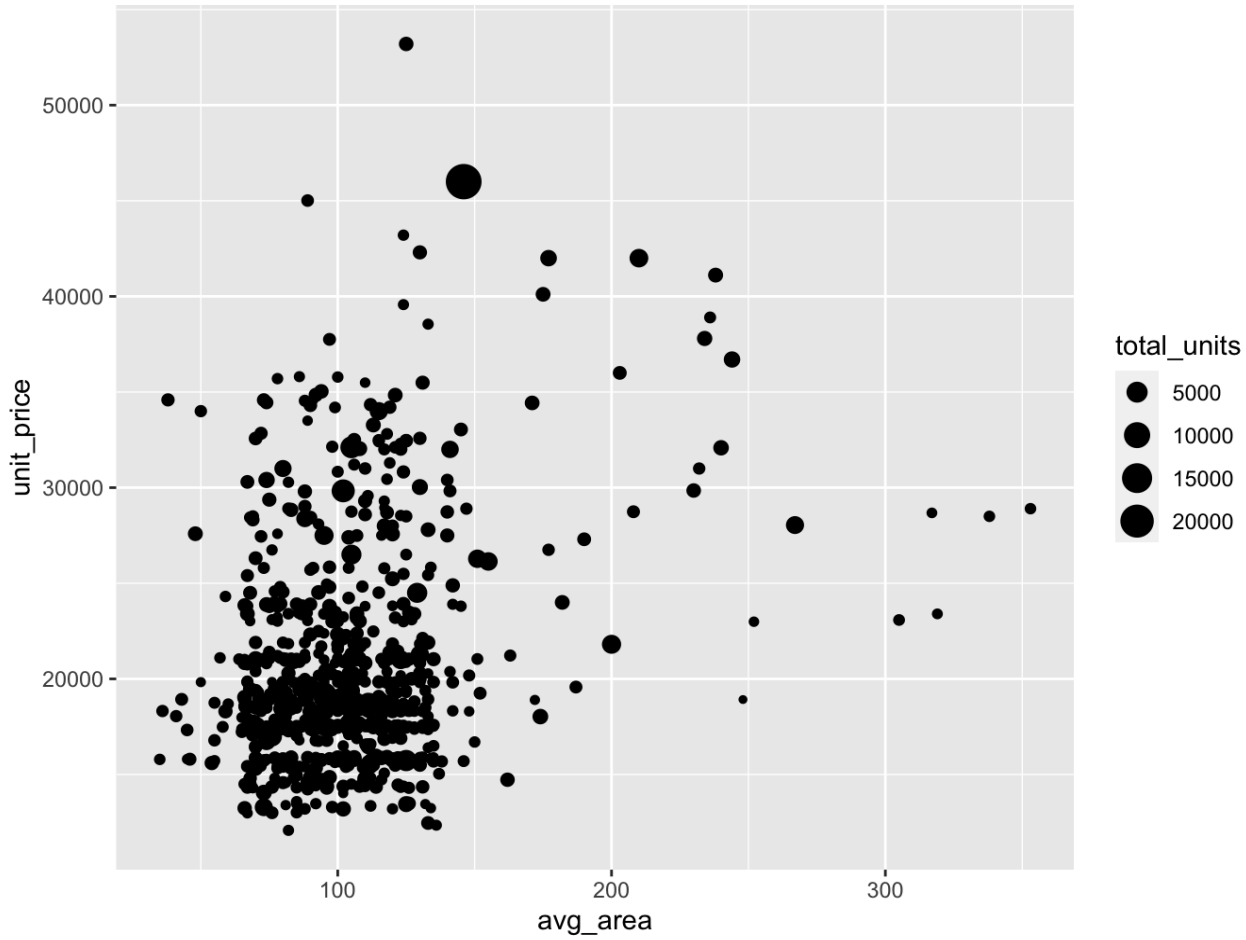
Figure 2. Aerial Image for Imputation Example.



In order to aid the imputation, I built the website using the Google Maps API to visualize the communities on a map of Wuchang. This became the structure for the final visualizer website (viewable here). To get the coordinates of the communities, the Baidu Maps API came in handy as it has more accurate results for searching Chinese locations. Another obstacle in this process is the different coordinate systems that maps of China use (as can be seen in the offset between Google Maps' satellite maps and the street maps for China). For this, the Baidu coordinates need to be converted to WGS84 coordinates used by Google Maps via the "coordtransform" package.

The imputation process is based on the aerial images and my understanding of residential properties in China (which also explains why I chose Wuchang as the location of the simulation, as I lived there prior to coming to the US). For instance, for the apartment building in the center of Figure 2, I estimate it to have 9 floors based on the balcony outline. Based on the overhead layout, specifically the location of stairwells, it can be deduced that each floor would contain 7 units. This brings the total number of units in the building to around 63. The area of the units can be estimated by observing all the buildings and units in a community, and averaging the overhead layout size.

Figure 3. Distribution of Communities in Wuchang District.



Note: each dot indicates one community, with the size of the dot denoting the size of the community in terms of number of units. Average area in m^2, unit price in RMB.

Table 2. Summary of Residential Units in Wuchang District

Communities	Units	Average Area	Average Unit Price
777	508,441	109.8m^2	22,882.8 RMB/m^2

The resulting data is summarized in Figure 3 and Table 2. For the simulation, several tax regimes are applied to the local tax base. For each community, the average area of units in the community, the total number of units, and the average unit price are used in the calculation of tax revenue under various regimes.

Step 2: Tax Revenue Simulation

To create a potential residential property tax regime, the tax base, tax rate, and tax rules are all significant. The tax base used in this simulation is all properties in Wuchang district with

quantile splits. Three tax rate regimes are tested with different rates for the tercile, quartile, and quintiles groupings, as shown in Table 3. Regime 1 is a uniform rate. Regime 2 is the progressive-harsh rate. Regime 3 is the progressive-accommodating rate. Regime 1 remains the same regardless of the quantile membership of the units. Both Regimes 2 and 3 have rates that vary with quantile membership, with Regime 3's rate being significantly lower than those of Regime 2. Regimes 2 and 3 are tested twice, with total price quantiles and total area quantiles. Each regime is tested under five exemption rules: no exemption, $30m^2$ exemption, $60m^2$ exemption, $120m^2$ exemption, and $180m^2$ exemption.

Table 3. Simulated Tax Rate Regimes

	Terciles	Quartiles	Quintiles
Regime 1	1.0%	1.0%	1.0%
Regime 2	0, 0.5%, 1.0%	0, 0.5%, 1.0%, 1.5%	0, 0.4%, 0.8%, 1.2%, 1.6%
Regime 3	0, 0.3%, 0.5%	0, 0.2%, 0.4%, 0.5%	0, 0.1%, 0.2%, 0.4%, 0.5%

The design of these rates inherits the spirit from the Chongqing and Shanghai pilots. For instance, the progressive rates based on property price is similar to the different rates that Shanghai and Chongqing implemented for different classes of properties. The exemption rules also cover similar ranges, as Shanghai exempts $60m^2$ per individual (likely resulting in over $100m^2$ exempt on average) and Chongqing exempt $100m^2$ per family. The main difference between the pilot programs and the simulation, then, is the inclusion of all properties in the tax base for the simulation, as opposed to the pilot programs' exclusive target of only newly purchased properties. In order to get the quantile membership of properties, I first flattened the community-level data to the property-level, then using dyplr mutate to add variables for each quantile group with the ntile function. The simulation is done using sapply in R to sum the revenue under various regimes with various exemption rules determined by ifelse statements.

Step 3: Web Calculator

The final step is to build a web calculator that both visualizes the data and makes clear the implication and potential effects of the property tax. The Google Maps API is the centerpiece of this part of the project. An interesting aspect is the customization of the markers for the communities. The Google Maps default is the read marker, which I found to be both less aesthetic and contained too little information (since it is just a dot on the map). Instead, I used the cloud-based map styling, which requires the creation of a mapId and specifying the map type, to allow the creation of custom markers that displays the average price and expands to show the community details. The markers contain the same information as the CSV data, but are converted into JSON format in R to store as local objects for the site.

The district boundary, shown in white outline on the website, is exported from OpenStreetMap as a geoJSON object. I later found that there is also the option to use the Google Maps API cloud-based map styling to include boundaries. To build the calculator, I initially thought of converting the property-level data from CSV format to JSON, and loading it onto the page. However, noticing the large size of such a file, I decided to take the more efficient approach of pre-calculating the total price for each quantile, storing those as constants, and using those sums as the user adjusts the tax rate sliders. This allows faster computation, however, it comes at the expense of not filtering for area-based exemption rules that would be possible with individual property-level data. (Note: technically, this could be pre-calculated as well, but doing so would only allow certain tiers of area-exemption, such as the 30, 60, 120, 180, in the simulation, and not a freely adjustable area-exemption rule.)

I considered using React for the website, as access to dynamic components would be helpful for DOM manipulation. In the final result, however, I found plain JavaScript to suffice mainly due to the simplicity of the calculations once the property-level data is not used. The text-boxes are made interactive and draggable with jQuery UI, and the project overall is hosted on Netlify with a split-off branch from the main GitHub repository.

Results

The results of the simulation are displayed in Table 5. Each row represents the specific tax rule. Each column represents the base-rate pairs. At a glance, the revenue increases as quantiles become finer, with revenue from Regime 2 being the highest on average. Furthermore, quantile membership based on price and area yield nearly identical revenue. These observations are explained by the highly linear relationship between price and area, as can be seen in Figure 4. For property tax to be a meaningful substitute to land finance revenue, revenue from the tax should be compared to that from land finance. Table 4 presents the historic land finance revenue in Wuchang, and the average land finance revenue in Wuchang over the three years pre-property market downturn is 15.1 billion RMB. The base-rate-rule combinations that yield roughly comparable revenue figures are highlighted in Table 5.

Table 4. Land Finance Revenue in Wuchang District

2019[3]	2020[4]	2021[5]	2022[6]	2019-2021 Average (Simulation Target)
17.52	15.25	12.54	5.41	15.10

Note: in billions of RMB

The many highlighted cells suggest that property tax does have the potential to substitute land finance. However, several qualifications are required. First, the lack of exemptions in the first two rows make them especially unpalatable to the public and thus difficult to implement. Revenue from rules with 120m^2 exemption show a precipitous drop from that from the 60m^2 exemption rule, which is expected as the average area of residential units in Wuchang is 109.8m^2, as Table 2 shows. The distribution of units in Figure 3 also shows that indeed the vast majority of units in the simulation are below the 120m^2 cutoff. Judging from the numbers in Table 5, the ideal tax base-rate-rule combination that both substitutes for land finance revenue and takes popular pressure into account as much as possible would be a quintile-based rate that is slightly higher than Regime 3 with around 60m^2 of average exemption.

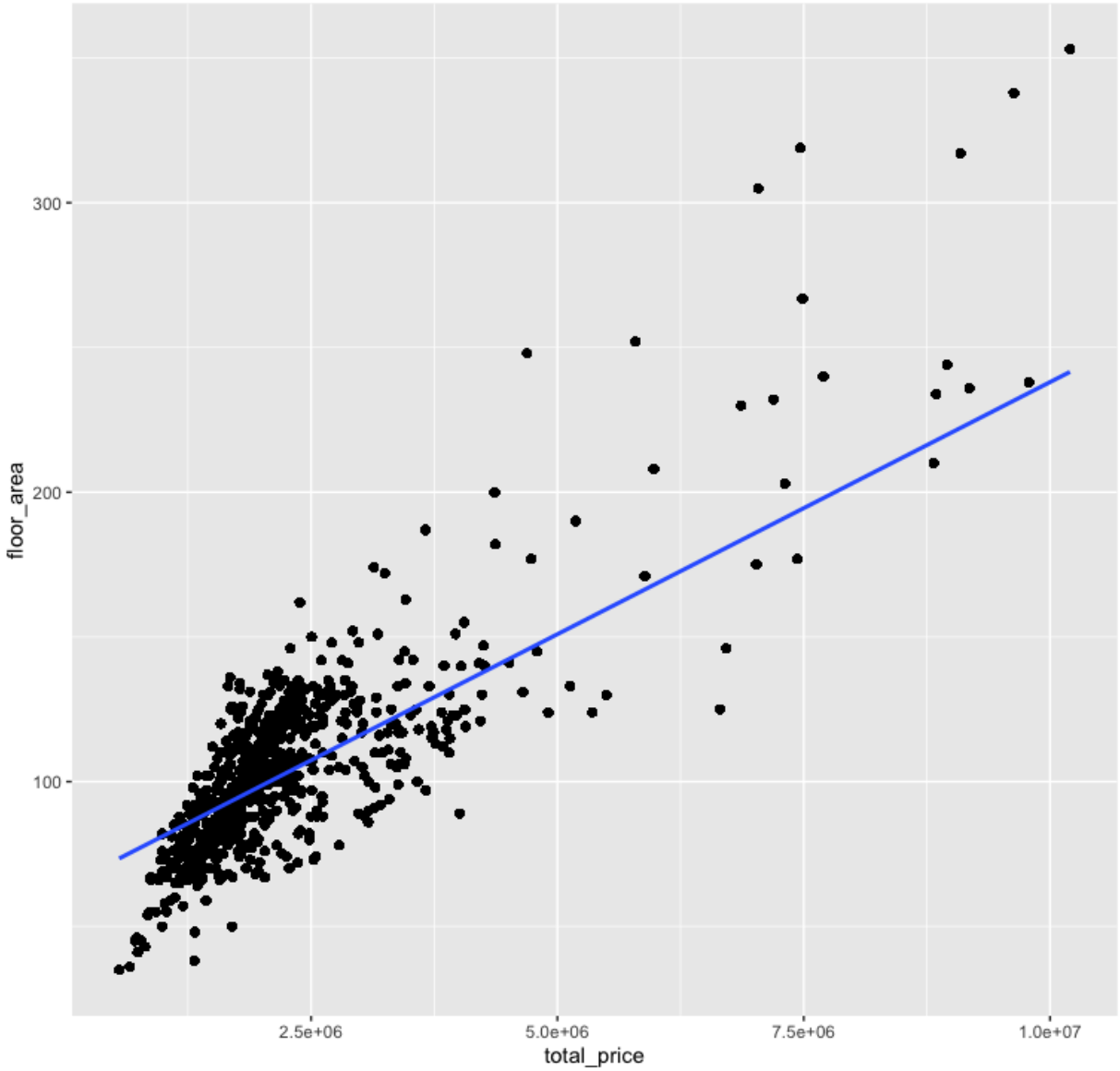
[3] Wuchang Finance Bureau, "关于调整武汉市武昌区2019年财政收支预算的报告 [Report on the Adjustment of Wuchang District's Fiscal 2019 Revenue and Expenditure Budget]," Wuchang People's Government, December 12, 2019, http://www.wuchang.gov.cn/zwgk_37/fdzdgknr/qtzdgknr/sjgk/czyjs/202005/t20200501_1218132.html.
[4] Wuchang Finance Bureau, "关于调整武汉市武昌区2020年财政收支预算的报告 [Report on the Adjustment of Wuhan Wuchang District's Fiscal 2020 Revenue and Expenditure Budget]," Wuchang People's Government, December 11, 2020, https://www.wuchang.gov.cn/ydd/sy_30000/xxgk_30003/czxx_30862/202012/t20201211_1550605.html.
[5] Wuchang Finance Bureau, "关于调整武汉市武昌区2021年财政收支预算的报告 [Report on Adjustment of Wuhan Wuchang District Fiscal Year 2021 Budget]," Wuchang People's Government, December 10, 2021, http://www.wuchang.gov.cn/xxgk/czj/fdzdgknr/czzj/czyjs/202112/t20211210_1870769.html.
[6] Wuchang Finance Bureau, "关于调整武汉市武昌区2022年财政收支预算的报告 [Report on the Adjustment of Wuhan Wuchang District 2022 Financial Revenue and Expenditure Budget]," Wuchang People's Government, December 15, 2022, https://www.wuchang.gov.cn/zwgk_37/fdzdgknr/czxx/czyjs/202212/t20221230_2122827.html.

Table 5. Tax Revenue Under Different Simulated Tax Regimes

	Regime 1	Terciles		Quartiles		Quintiles	
		Regime 2	Regime 3	Regime 2	Regime 3	Regime 2	Regime 3
Total Price	13.40	20.10	10.72	40.21	14.74	53.61	16.08
Area		20.10	10.72	40.20	14.74	53.61	16.08
Total Price, $30m^2$ exempt	9.91	14.87	7.92	29.73	10.90	39.65	11.89
Area, $30m^2$ exempt		14.87	7.92	29.73	10.90	39.65	11.89
Total Price, $60m^2$ exempt	6.44	9.67	5.55	19.33	7.09	25.78	7.73
Area, $60m^2$ exempt		9.67	5.15	19.33	7.09	25.78	7.73
Total Price, $120m^2$ exempt	1.43	2.14	1.14	4.29	1.57	5.72	1.72
Area, $120m^2$ exempt		2.14	1.14	4.29	1.57	5.72	1.72
Total Price, $180m^2$ exempt	0.34	0.52	0.28	1.04	0.38	1.39	0.42
Area, $180m^2$ exempt		0.52	0.28	1.04	0.38	1.39	0.42

Note: in billions of RMB

Figure 4. Relationship Between Total Price and Floor Area in Wuchang



Note: each dot indicates one unit, floor area in m^2, price in RMB

The web calculator can be adjusted to give results with greater granularity. While the calculator does not present options for area-based exemptions, it offers greater clarity with a clear, dynamic substitution percentage and tax as income share. This offers another aspect to the result found above. If the revenue is to approach 100 percent of historic land finance revenue, the tax would have to consume around 20 percent of the disposable income of residents. This constant result makes sense, as using property tax to substitute for land finance is essentially translating the revenue burden from property developers to residents. Although under the land finance revenue model, the people are still the final bearer of the revenue via higher property prices, it was a more specific group of people — homebuyers. In the property tax model, all homeowners would bear that revenue burden.

This begs the question of whether such levels of taxation would be socially acceptable or economically sustainable in China. In the US, the average person pays $2,471 in property taxes per year,[7] whereas the per capita disposable income is around $48,219 in 2021.[8] Only about 5 percent of the disposable income goes toward property tax. In comparison, the 20 percent that is required in Wuchang seems to be an unrealistic burden given that China is less developed and the potential of crowding out private consumption, an emerging pillar of China's economy. On the other hand, if the tax is designed to only take up around 5 percent of resident income, then the revenue would not be more than 27 percent of the historic land finance revenue.

Future Direction

Still, the simulation and calculations above reflects a very idealistic case, and several potential issues should be noted: data accuracy, location representativeness, and tax rule limits. First, the data of communities in Wuchang might not be accurate due to potential imputation errors, reliance on averages at community-level instead of individual units, and the exclusion of dwellings outside of communities, such as shantytowns.

Table 6. Comparison of Wuchang District to Rest of China

	Wuchang	Wuhan	Hubei	China	Shanghai	Chongqing
Per Capita GDP	120,205	144,695	77,387	10,144	157,300	75,828
Per Capita Income (Urban)	57,501	51,706	37,601	30,733	73,615	37,939

Note: in RMB
Source: 2019 Yearly Statistical Bulletins[9] [10] [11] [12] [13] [14]

[7] Liz Knueven, "The Average Amount People Pay in Property Taxes in Every US State," Business Insider, July 1, 2021.
[8] "U.S. Disposable Income per Capita 2000-2018," Statista (Statista, 2018), https://www.statista.com/statistics/710215/us-disposable-income-per-capita/.
[9] "武昌区2019年国民经济和社会发展统计公报 [Wuchang District 2019 National Economic and Social Development Statistical Bulletin]," Wuchang People's Government, September 27, 2020, https://www.wuchang.gov.cn/zwgk_37/fdzdgknr/tjxx/tjgb/202009/t20200927_1456228.html.
[10] National Bureau of Statistics, "2019年居民收入和消费支出情况 [2019 Resident Income and Consumer Spending]," The Central People's Government of the People's Republic of China, January 17, 2020, http://www.gov.cn/xinwen/2020-01/17/content_5470095.htm.
[11] "2019年武汉市国民经济和社会发展统计公报 [2019 Wuhan National Economic and Social Development Statistical Bulletin]," Wuhan Bureau of Statistics, March 29, 2020, http://tjj.wuhan.gov.cn/tjfw/tjgb/202004/t20200429_1191417.shtml.
[12] "湖北省2019年国民经济和社会发展统计公报 [2019 Hubei Province National Economic and Social Development Statistical Bulletin]," Hubei Bureau of Statistics, March 23, 2020, http://tjj.hubei.gov.cn/tjsj/tjgb/ndtjgb/qstjgb/202003/t20200323_2188487.shtml.
[13] "2019年上海市国民经济和社会发展统计公报 [2019 Shanghai National Economic and Social Development Statistical Bulletin]," Shanghai Bureau of Statistics, March 2020, https://tjj.sh.gov.cn/tjgb/20200329/05f0f4abb2d448a69e4517f6a6448819.html.
[14] "2019年重庆市国民经济和社会发展统计公报 [2019 Chongqing National Economic and Social Development Statistical Bulletin]," Chongqing Bureau of Statistics, March 19, 2020, https://tjj.cq.gov.cn/zwgk_233/fdzdgknr/tjxx/sjzl_55471/tjgb_55472/202003/t20200330_6686410.html.

Second, Wuchang is converging toward the most developed regions in China, which means that the potential property tax revenue in the district would be on the higher end. As Table 6 shows, Wuchang's per capita income is nearly twice the national average and per capita GDP is nearly 12 times the national average. While the simulation is still instructive for many metropolitan areas in China, in reality, the odds of substituting land finance revenue are highly dependent on the locality's tax base and industries. A municipal district that is still urbanizing might rely more on land finance revenue and have less property tax base, resulting in lower chance of substitution and greater extent of crowding out of private consumption should full substitution be expected. Thus, whether the same calculations will work out at the city-level when all districts in Wuhan, let alone all of China, are considered is still in question. More simulations at larger scales will be required to answer that question.

Finally, for many smaller cities, property prices might be more sensitive to property tax, which means that adoption of the tax might lead to greater reduction in private wealth, thereby triggering a stronger social backlash. The property tax rate adopted by many countries is around 1 percent, but the ability of certain Chinese cities to withstand a 0.5 percent rate remains uncertain.[15] Yet if the tax rate is too low, it cannot achieve the effect of improving local government finances. Therefore, it might be necessary to consider a heterogenous tax model that varies across regions, not reflected in the simulation. The simulation also does not reflect other rules such as the migrant-local distinction in both the Chongqing and Shanghai pilots.

A natural next step would be to expand the analysis and simulation to more regions in China with the scraping script. However, it should still be noted that the method's effectiveness might be limited to urban areas, as Fang.com does not contain listings from rural areas. Additionally, this analysis assumes that the property tax will have to make up for the entirety of historic land finance revenue. Taking into account that land finance will likely not vanish after the tax's introduction, there can be a subsequent analysis that takes the effect of property tax, at different rates, on property prices, and see if there is an ideal tax rate at which the decrease in land revenue is equal to the tax revenue — this will provide more policy instructions.

Conclusion

Overall, this project finds that the apathy from Chinese local governments regarding the property tax is not unfounded. Despite the tax having potential to bring in extra revenue, it contradicts the local governments' existing revenue generation model that relies on land finance revenue. Furthermore, while the tax has the potential to replace the loss in land finance revenue post-property market downturn, achieving such a level of taxation would come at the expense of private consumption. Such a reality would be politically, socially, and economically difficult to stomach for the Chinese government. As a result, should property tax collection start in the near

[15] Jing Cao and Wenhao Hu, "A Microsimulation of Property Tax Policy in China," *Journal of Housing Economics* 33 (September 2016): 128–42, https://doi.org/10.1016/j.jhe.2016.05.004.

future, it would be due to the political qualities (such as its role in President Xi's common prosperity campaign and goal of controlling real estate speculation) of the tax, more so than the economic qualities (if it is designed to be at around 5% of residents' disposable income, it would only ever supplement local government revenue and not replace the role of land finance).