Article

Evaluating accessibility benefits of opening gated communities in China: a case study of Shanghai

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Abstract: Opening gated-communities (GCs) has been widely discussed for urban inclusion and revitalization. With the policies of opening GCs being promoted in China, quantitative and comprehensive evaluation of the potential benefits is heavily needed. Taking Shanghai as an example, this study quantifies and analyzes the accessibility benefits and risks of opening GCs with factors including GC types, opening levels, travel modes, and travel destinations considered. We found that (1) opening GCs can bring 50m+ accessibility gains to 17% and 52% of the residents in Moderately Opening (MO) and Completely Opening (CO) scenarios, respectively. (2) Cycling benefits more than walking in all cases and scenarios. (3) For different GCs, conventional GCs have fewer benefits in MO but more in CO than the newly-established one. For different facilities, trips to bus stations demonstrate the largest accessibility gains. (4) The accessibility benefit of a residential building is highly determined by its closeness to the gates and relative location in the block. (5) Only 1% and 5-7% of external trips may penetrate the opened communities in MO and CO scenarios, respectively, which are far less than both expectation and the benefits. These findings precipitate at least two policy implications in China.

Keywords: Gated Communities; Opening Scenarios; Accessibility Benefits; Evaluation; Shanghai

1. Introduction

Gated community (GC) is a longstanding residential estate pattern in China. In the early phase of People's Republic of China's foundation, soviet-style residential estates that featured by grand roads and superblocks were widely adopted in urban planning [1, 2], creating great amounts of gated "work units" where residence and employments are well balanced [3, 4] and forming a typical cityscape in China. After China's reform and opening-up since 1970s, the "acquaintance society" in the conventional GCs started to confront disintegration and renewal [5]. Meanwhile, the new housing estates developed by private companies took the form of GC, making it one of the dominant forms of residential estates in China in both urban and rural areas [4, 6].

Though widely adopted, GC is widely criticized for negatively affecting both the internal living quality and external urban environments. As for interior residents, they have to take the strain of high housing prices and property costs [7] but unable to enjoy public spaces inside the neighboring communities. Moreover, without connections to a larger urban environment, the semi-private internal streets in GCs can hardly support a social life with insufficient diversity of pedestrians [8]. As for the exterior urban area, GC fosters traffic congestion and high automobile dependency [9]. Researchers estimate that residents from GCs in superblocks use 65% to 80% more transit energy than those living in mixed-use, walkable neighborhoods [10]. Furthermore, GC also causes fragmentation and polarization in sociocultural aspects [11]. All these drawbacks inspire the exploration of GCs' opening-up. As the urban regeneration in China shifting from "superblock-centered" to "street-centered" [12], an open block system is strongly promoted by the government. In 2016, "opening gated residential communities to public road system" was first put forward in official documents, stressing that newly established communities should adopt the block system. Another official document, Shanghai Street Design Guidelines (SSDG), encourages opening the main internal roads in large-scale GC for pedestrians and cyclists. In 2017, the urban renewal projects represented by opening GCs were launched in a few large Chinese cities, such as Changsha, Chongqing, and Nanjing. Since 2018 the opening policies have been released in middle and small size cities, highlighting government's attention to revitalization of GC and its adjacent urban areas. The exemplar cases are Yulin community in Chengdu, Gubei community in Shanghai, and Guogongzhuang public rental housing project in Beijing.

Prior studies have explored multiple aspects of GCs' (re)development, involving both the benefits and the risks of the opening-up. Some researchers found that opening GCs provides great benefits, including enhancing spatial accessibility, strengthening social-cultural connection, and improving low-carbon transport by creating a more walkable and bikeable environment [9]. Opening strategy is also highly praised by urban practitioners. One study demonstrates that for urban planners, adding additional entrances is ranked the second place among multiple spatial interventions towards GC [13]. However, some researches argue that the opening-up will negatively affect some households [14]. In a recent study, five types of pressure brought by opening GCs are revealed as site redesign, urban governance, social frictions, legal status, and a financial burden [15]. In summary, no consensus has been reached on the evaluation of opening GCs.

Although the effects of opening GCs have been widely discussed, there still exist some limitations. Most studies, no matter based on qualitative or quantitative approaches, seldom consider factors including GCs' characteristics, travel modes, and travel destinations, which may lead to discrepancies in the benefits of opening GCs. Furthermore, the risks accompanied by opening the gates have been noticed but never measured or surveyed.

Taking Shanghai as the case, this paper focuses on quantifying and analyzing the accessibility benefits as well as the potential risks brought by opening the GCs. To incorporate the aforementioned factors, we select two typical GCs and quantify the accessibility benefits in various opening scenarios with respect to multiple categories of facilities and for both pedestrians and cyclists. Quantitative analysis is carried out combining activity models and the data from Comprehensive Transportation Survey, census data, and online mapping services.

This paper is organized as follows: Section 2 provides a literature review of GC's formation and influences. Section 3 describes our metrics, scenario design, and data processing. Section 4 evaluates the overall accessibility benefits of opening GCs and explores the discrepancies between two communities, cyclists and pedestrians, different categories of facilities, and different scenarios. Finally, Section 5 presents the conclusion and discussions.

2. Literature review

2.1. Gated community formation and urban development in China

The gated community (GC) originated from the West is a type of residential development that has secured entrances and are surrounded by walls, fences, or earth banks covered with bushes and shrubs [16], which is initially established to provide the upper-income rank security and honor. During the suburbanization in 1960s, downtowns in many western cities declined and consequently, amounts of rich people moved to suburbs for the better living environment. In order to attract the middle classes back to downtown and revitalize city development, many GCs were then built within the cities. In brief, GCs and current urban policies seek similar ends, which is the promotion of the city as a place to live for the middle classes [17].

Being a typical manifestation of enclave urbanism [18], the Chinese GCs are different from the western form in its larger scale, higher density, and serving the mixed-level income classes [19]. The reason for these differences is its unique historical origin, based on which Chinese GCs can be divided into two types. The first type dates to the planned economy period and is still common today in downtown areas of big cities, including Shanghai and Beijing. After the founding in 1949, urban neighborhoods in China were reorganized as productive units called "dayuan" or "danwei", which emerged as the first form of GCs in China. Gates in these GCs are used to segregate not only residential estates but also the production places and even the power space. For example,

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administrative bureaus and state-owned-companies usually built exclusive communities for employers, where outsiders are ineligible to enter or reside. Since the 1978 economic reform, these productive units have been constantly penetrated by private business, becoming more and more inhomogeneous [19].

Another type of GCs has a similar origin to its western counterparts. After 1978 with the increase of middle and upper classes, new housing estates were built outside the old city area and took the form of GC that can provide an upmarket neighborhood to attract residents. The new-born GCs grew rapidly in the metropolitan periphery [20], characterized by large-scale blocks and internalized public space. This type of GC and the renewed productive units in the old city area together comprise two typical categories of urban GCs in China.

2.2 Debates about gated community

A GC produces clear benefits for internal residents. The widely recognized positive effects of GCs includes increased security [21], better privacy [13], greater efficiency in exclusive service provision [22, 23], and a stronger sense of place attachment [24]. From another aspect, GCs also offer an escape from outside pollution and vehicles [25].

Nevertheless, considerable amounts of studies also propose that GCs have harmful effects on urban society. Many researches demonstrate that GC deepens social polarization [26-28]. In one study, GCs are interpreted as an internal simplification which will inevitably increase social tensions and exacerbate social cleavages among communities [29]. A recent study also puts forward that as one of the important spatial representations of gentrification in China, GCs further weaken and destroy neighborhood relationships [11].

Accompanied by such influence exerted on social structure, the quality of public spaces in GCs also declined. Pseudo-public spaces increased [30] and characterized by similar, minimum-level facilities (a central green space, sometimes plus a clubhouse) [19]. The more the public spaces are privatized by the affluent class, the more free-access green space provision decreases [28], which primarily affects low-income renters and leads to many social problems [7].

Additionally, GC is blamed for negatively affecting urban transportation and the environment as it causes detours for outsiders. GC is criticized not only for damaging the overall connectivity of urban space but also having a negative effect on the choice of low-carbon transportation [31]. Recent literature even finds that the main reason pedestrians accessing metro stations were deviating from the shortest station access path is the presence of GCs [32]. Some researchers also demonstrate that the expansion of GCs generates much more traffic congestion and pollution from hydrocarbon emissions [22].

In essence, these hazards are attributed to GCs' negative impact on the openness, transparency, and accessibility of cities [17]. To be more specific, GCs provide huge challenges to the traditional porosity and democracy of the street [21], which triggers the method of opening the gates and reconnecting the roads. Not only can openness erase the traffic congestion by expanding the micro-road network [33], it can also increase the overall connectivity and accessibility of the current road network and alleviate the urban traffic problem [34]. As an efficient and low-cost solution to improve the overall isolation of GCs, some researches tried to explore the benefit in a more specific way. For example, there is one study that uses the "permeability" change in network analysis to illustrate the improvement of opening gates [35].

To sum up, the major defect in existing studies is the lack of quantitative evaluation of the accessibility benefits of opening GCs with more realistic factors taken into account. Therefore, this study endeavors to fill the gap by evaluating the accessibility benefits regarding two typical GCs and various opening scenarios.

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3. Methodology and data

3.1 Accessibility benefits quantification and metrics design

This paper quantifies the accessibility benefits combining activity models and assumed opening GC scenarios. An accessibility benefit of opening GC simply refers to the saving percentages of cumulative travel distances or the proportion of potential routes that with the reduced distances exceed some thresholds. More specifically, the total benefit of distance provided by opening a GC is given by,

$$B_{total}^{distance} = \frac{\sum_{\boldsymbol{i}}\left[T_i \times \sum_j P_{ij}(d_{ij}^{barrier} - d_{ij}^{open})\right]}{\sum_{\boldsymbol{i}}\left[A_i \times \sum_j P_{ij} d_{ij}^{barrier}\right]}$$

$$P_{ij} = \frac{e^{-\gamma d_{ij}}}{\sum_j e^{-\gamma d_{ij}}}$$

where $d_{ij}^{barrier}$ is the present travel distance from residential building i to a destination j without any opening procedure, d_{ij}^{open} is the travel distance from i to j under a scenario in which some new gates are opened. P_{ij} is the travel probability from i to j that calculated by a single-constrained gravity model, T_i is the total numbers of trips that originate from i, so that the products $T_i \times \sum_j P_{ij} d_{ij}^{open}$ and $T_i \times \sum_j P_{ij} d_{ij}^{barrier}$ refer to the cumulative travel distances that originate from i with or without any opening GC policy.

To provide a more precise quantification, T_i is further subdivided into different activity types and corresponding facilities. This paper takes into account four types of facilities: bus station, metro station, daily services, and sports & entertainment. The latter two categories are extracted combining the activity types defined in the comprehensive transportation survey in Shanghai and the point-of-interests (POI) types defined by the online mapping servicers in China so that the T_i can be well estimated based on real activity patterns.

$$T_i^k = A_i D_{pop} \mu^k$$

where A_i is the residential building area of building i, D_{pop} is the average population density in Shanghai regarding residential building area, and μ^k is the average travel frequency (person/day) regarding facility k.

The metric $B_{total}^{distance}$ measures the absolute savings in travel distance when gates are opened. However, since the detour caused by community gates are generally limited by the size of urban blocks (e.g., 100m), the fraction of it in the total travel distances would be comparatively small if we consider trips as long as, e.g., 2km. In fact, since people choose to walk mostly when travel distances are less or around 400m [36], a saving of 50m in opening scenarios may be sufficiently perceptible for people to support and act for such policies.

Therefore, in order to eliminate the effect of travel distance on the absolute accessibility benefit $B_{total}^{distance}$, we propose another metric B_{total}^{count}, which measures the proportion of benefitted OD that have their distances drop by at least 50 meters:

$$B_{total}^{count} = \frac{\sum_i \sum_j A_i P_{ij}\, I(d_{ij}^{barrier} - d_{ij}^{open} > 50m)}{\sum_i \sum_j A_i P_{ij}}$$

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where I is an indicator function to detect whether the saved distance exceeds 50m. If 10% of the trips can perceive accessibility improvements, even though the average distance ($B^{distance}_{total}$) savings are relatively small, opening policy may still be welcomed. Finally, it should be noted that both $B^{distance}$ and B^{count} can be calculated either by aggregating the trips originated from all buildings in one community or from each building to specific facilities.

Moreover, the penetration risk $risk^{count}$ is defined in a similar way as B^{count}_{total},

$$risk^{count} \frac{\sum_i \sum_j B_i P_{ij}\, I(d^{barrier}_{ij} - d^{open}_{ij} > 50m)}{\sum_i \sum_j B_i P_{ij}}$$

where B_i is the residential building area of building i that located within the neighboring 500m from the case communities. Again, we presume that if the saved distance exceeds 50m, the neighbor residents may choose to penetrate the opened GCs.

3.2 Scenario design

As summarized in Table 1, two scenarios are modeled. One is the Moderately Opening scenario (MO), in which the fake gates, those built but not actively used ones are assumed to be opened. Note that there are two types of fake gates as shown in Figure 1. Some fake gates, namely locked gates, are set but completely closed, blocking all potential walkers, cyclists, and automobiles. Other fake gates, namely pedestrian gates, are equipped with rotating doors so that all accesses are restrained except for walkers. To demonstrate such difference, we measure the accessibility benefits for walk and bicycle, respectively.

Another scenario is the Completely Opening scenario (CO), in which we not only open the fake gates but also add new gates with reasonable interval distance by breaking the walls. The new gates are determined mainly based on the grids of the major roads within the community, which should be planned as entrances from the perspective of the latest Opening Community Policy.

Table 1. Scenario design.

Scenario	Definition	Affected Travel modes	Gated by
Current situation	No opening policy	Walk	Wall +Pedestrian Gates
		Cycling	Wall + Pedestrian Gates +Locked Gates
Moderately Opening	Open existing gates	Walk& Cycling	Walls
Completely Opening	Break the walls	Walk& Cycling	Almost None

(a) (b)

Figure 1. Exemplars of Locked gates (**a**) and pedestrian gates (**b**).

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Figure 2 depicts a virtual community with two existing gates (where the community roads are linked directly to the city road network) and one fake gate (the thick red line). As one can expect, when no opening policies are implemented, the residents in building O1 suffer the most from the gates and walls, while residents in building O3 can easily access to D1 or D3 by walking but cycling. In contrast, O1 generally has better accessibility to all facilities. In MO, as the only fake gate will be opened, O3 benefits significantly for D1 and D3. O1 and O2 also benefit slightly for D1. In CO, four new entrances (green nodes) will be added considering the grid of the major community roads and the intervals. O2 and O3 will benefit remarkably for the facilities in the direction of D2 and D1, respectively. O1 also benefit slightly for some facilities.

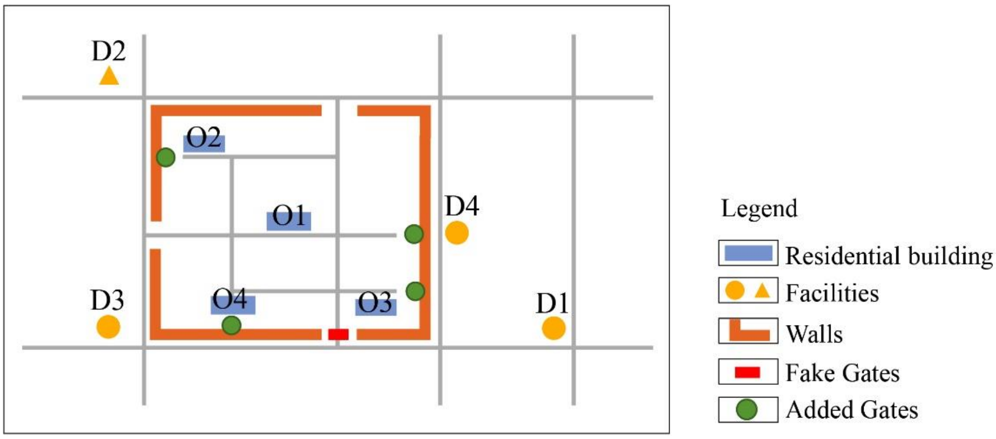

Figure 2. Diagram of a virtual gated community.

3.3 Data preprocessing and cases selection

Two cases are chosen according to different formation and development of GC mentioned in Section 2.1. The Yangpu community is the first type of GC in the old city, developing from working units which have a history of more than a half-century. The Pudong community is the second type of new-born GC in new urban areas, characterized by larger block size and community-owned central public space. As shown in Figure 3, the research area is delimited within 2km of each community, considering the general tolerance of pedestrians and cyclists. Since the detours caused by GC are generally limited by the size of urban blocks, the benefit brought by opening the gates for long-distance travel by car is negligible.

Four categories of facilities are encompassed, which are bus station, metro station, daily services (shopping, catering, and services), and sports & entertainment. The first two categories are considered because they are the most common facilities related to daily mobility. The latter two categories are extracted combining the activity types defined in the Comprehensive Transportation Survey in Shanghai and the point-of-interests (POI) types defined by the data provider in China (amap.com, one of the largest online mapping services in China). The activity frequencies of residents to visit different facilities (μ^k) are derived from the Comprehensive Transportation Survey. The number of residents in each parcel was allocated from each district available in the census report based on the floor area of each parcel.

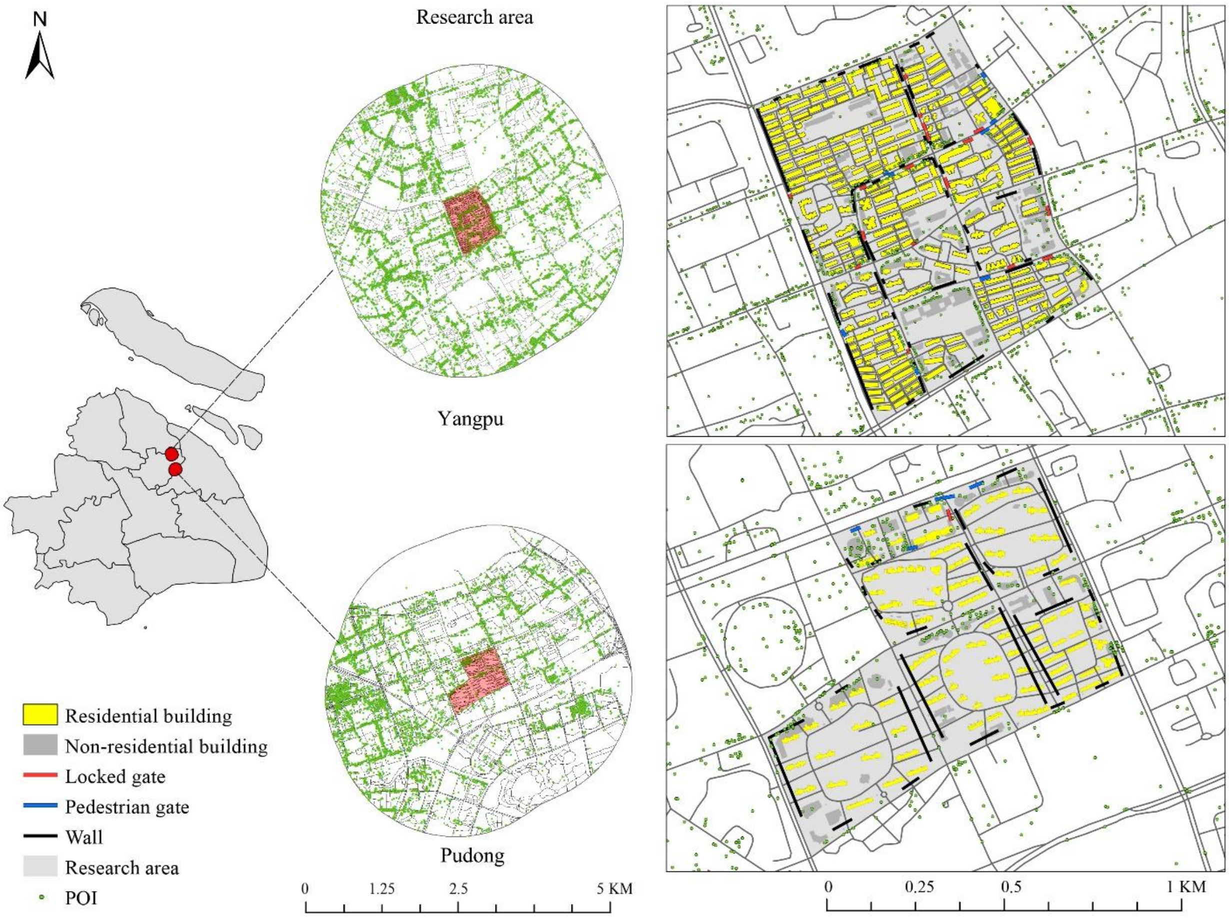

Figure 3. Research cases.

4. Results

4.1 Overall accessibility benefits

In general, we find that opening GCs can provide significant accessibility benefits, which, however, may vary dramatically as the metric changes. When measured by reductions in the cumulative trip distance (b^{dist}), this benefit is seemingly limited. As shown in Table 2 in both Yangpu and Pudong cases, the MO improves walking and cycling accessibilities by no more than 3% and 5%, respectively. Even in the CO scenario, which removes all the surrounding walls, the reduction percentages of trip distances by walking and cycling are only 5.7% and 11.8%. The numbers are small due to two reasons. On the one hand, opening the GCs mainly reduces the detour distances within the communities, which are naturally limited to no more than the size of urban blocks, producing generally constrained values of the nominator of b^{dist}. On the other hand, our evaluation takes into account the destinations with distances up to 2km to the origins, which may generate relatively long trips and increase the values of the denominator of b^{dist}. In the case of 1km trips, a 5% saving in the distance averagely equals to 50m reduction, which could be a subjectively perceivable benefit.

The accessibility benefits are more significant in the count-based metric, b^{count}, which measures the proportion of OD pairs that have sufficiently perceptible accessibility benefits. Our result shows that the accessibility improvements brought by CO in both cases have reached about 40-50%. That is to say, if all kinds of gates and walls are completely removed, nearly half of travels from both communities will benefit from distance-reduction by more than 50 meters, which may bring residents a huge sense of accessibility improvement. For the MO scenario, the Yangpu community still displays significant accessibility benefits, 9.1% for walking and 17.7% for cycling, respectively, which are far

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beyond the percentages revealed by b^{dist}. In contrast, b^{count} in the Pudong case and MO scenario is much smaller than the Yangpu case and demonstrates little difference from b^{dist}. However, under the CO scenario, the benefits in the Pudong case surpass Yangpu distinctly, not only in distance savings but also in the count metric. We speculate that the reason is that the Pudong case is a renewed community that has only 6 unusable gates (fake & only for walk) but relatively tight walls, while the Yangpu case has 26 unusable gates, making the Pudong case benefits less from the MO, that is opening the unusable gates, but more from the CO. This indicates that suitable opening policies regarding different gated communities may vary dramatically according to their characteristics, such as gates' configurations.

Another distinct pattern is that the improvements for cycling accessibility are generally higher than that for walking in all cases and all scenarios. This is because Yangpu and Pudong cases have 8 and 4 pedestrian gates, respectively, which are unimpeded for pedestrians but physically impassable for bicycles and cyclists. Since such gates are common in Shanghai and presumably also in other Chinese cities, the revealed accessibility benefits for cycling emphasize the appropriateness of widespread implementation of opening such gates for bicycles.

Table 2. Overall accessibility benefits.

	Yangpu		Pudong	
	Walk	**Cycling**	**Walk**	**Cycling**
Moderately Opening (MO)				
distance	1.6%	2.4%	0.2%	4.2%
count	9.1%	17.7%	0.7%	5.1%
Completely Opening (CO)				
distance	4.9%	5.7%	8.1%	11.8%
count	40.0%	49.5%	49.9%	52.0%

4.2 Accessibility benefits regarding different facilities

The accessibility benefits of opening gates regarding different facilities are consistent with the overall trends in Section 4.1: the CO scenario has much more improvements than MO, the count metric reveals larger proportions of perceptible trips, the Pudong case has fewer benefits in MO, but more in CO, and the improvements for cycling accessibility are generally higher than for walk.

However, there are still distinctions between the accessibility benefits regarding the four types of facilities. Table 3 presents the benefits of four facilities under sixteen combinational situations (two metrics, two opening scenarios, and two travel modes for two cases). The bus station demonstrates the largest accessibility improvements 8 times out of the 16 situations. In contrast, although as public transport facilities, the accessibility improvements of metro stations polarize between the two cases. Trips from Yangpu community to metro stations constantly have the least accessibility benefits, while the Pudong case benefits significantly by both walking and cycling, especially when measured by distance. We speculate that the reasons are: (1) metro stations are sparser than bus stations, which accounts for less chance of accessibility benefit, and (2) meanwhile, because the Pudong community is a renewed modern estate whose gates configuration is mainly based on considerations for private cars' convenience so that its gates are located more closed towards the arterial roads rather than metro stations.

Unlike the public traffic facilities above, the accessibility benefits regarding daily services and sports & entertainment appear to be the most stable. The benefits of these two types of facilities mostly coincide with the average value in Table 2. For example, $b^{distance}$ and b^{count} of these two facilities in the CO scenario is around 6-9.5% and 40.2-51.6%, which is exactly within the range shown in Table 2. This is because, since these two types of facilities are more widely and homogeneously

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distributed than public traffic facilities, residents can always get access to them conveniently through existing gates so that only a few trips may benefit significantly from newly added exits.

Moreover, the benefits of cycling still generally prevail over walking, indicating again that cyclists in Shanghai suffer more from GCs no matter what their destinations are. Table 3 demonstrates that merely opening the fake gates can bring around 5% benefit for cyclists in Pudong, while a similar benefit for walkers is less than 0.8%. Obviously, such a disparity may be due to the fewer fake gates in Pudong case, as discussed in Section 4.1.

Table 3. Accessibility benefits regarding different facilities.

	Bus station	Metro station	Daily services	Sports &Entertainment
b^{count}				
Moderately Opening				
Yangpu				
walk	9.64%	8.75%	9.04%	9.27%
Cycling	17.61%	14.21%	17.82%	16.95%
Pudong				
walk	1.00%	0.63%	0.65%	0.79%
Cycling	6.19%	7.40%	5.00%	5.20%
Completely Opening				
Yangpu				
walk	39.18%	36.46%	40.22%	39.39%
Cycling	47.49%	42.56%	50.04%	47.76%
Pudong				
walk	50.63%	48.41%	49.85%	49.52%
Cycling	52.91%	51.80%	51.92%	51.62%
$b^{distance}$				
Moderately Opening				
Yangpu				
walk	1.98%	0.69%	1.64%	1.97%
Cycling	3.39%	0.76%	2.60%	2.71%
Pudong				
walk	0.16%	0.22%	0.13%	0.15%
Cycling	1.99%	6.09%	1.94%	1.64%
Completely Opening				
Yangpu				
walk	6.83%	2.94%	5.96%	5.74%
Cycling	8.17%	3.01%	6.87%	6.44%
Pudong				
walk	7.90%	8.42%	7.09%	8.16%
Cycling	9.58%	13.80%	8.76%	9.53%

Note: the row-wised maximum and minimum numbers are highlighted by red and blue, respectively.

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4.3 Spatial heterogeneity of the benefits

Spatial analyses show that significant heterogeneity of the benefits can be observed. Residents in the same community may have dramatically varying accessibility benefits, which are highly determined by 1) their closeness to the corresponding opened gates in specific scenarios, and 2) the relative location of the building in the block.

Figure 4 illustrates the effect of the first factor, closeness to the opened gates. In the MO scenario (left column in Figure 4), residents within 200m of the locked gates or pedestrian gates can receive benefits of b^{count} as high as 40% for walking and cycling, though in the Pudong case, such benefit is not common because it has only five fake gates. However, in the CO scenario, there exists almost no correlation between distance to opened gates and b^{count} (right column in Figure 4). This is because, in CO scenario, all the accessibility shortcomings regarding each pair of residents and facilities can be generally overcome since gates are added in every wall, as depicted in Figure 2. This result demonstrates that spatial heterogeneity caused by the first factor can be counteracted in the ideal opening scenario, though at great expense.

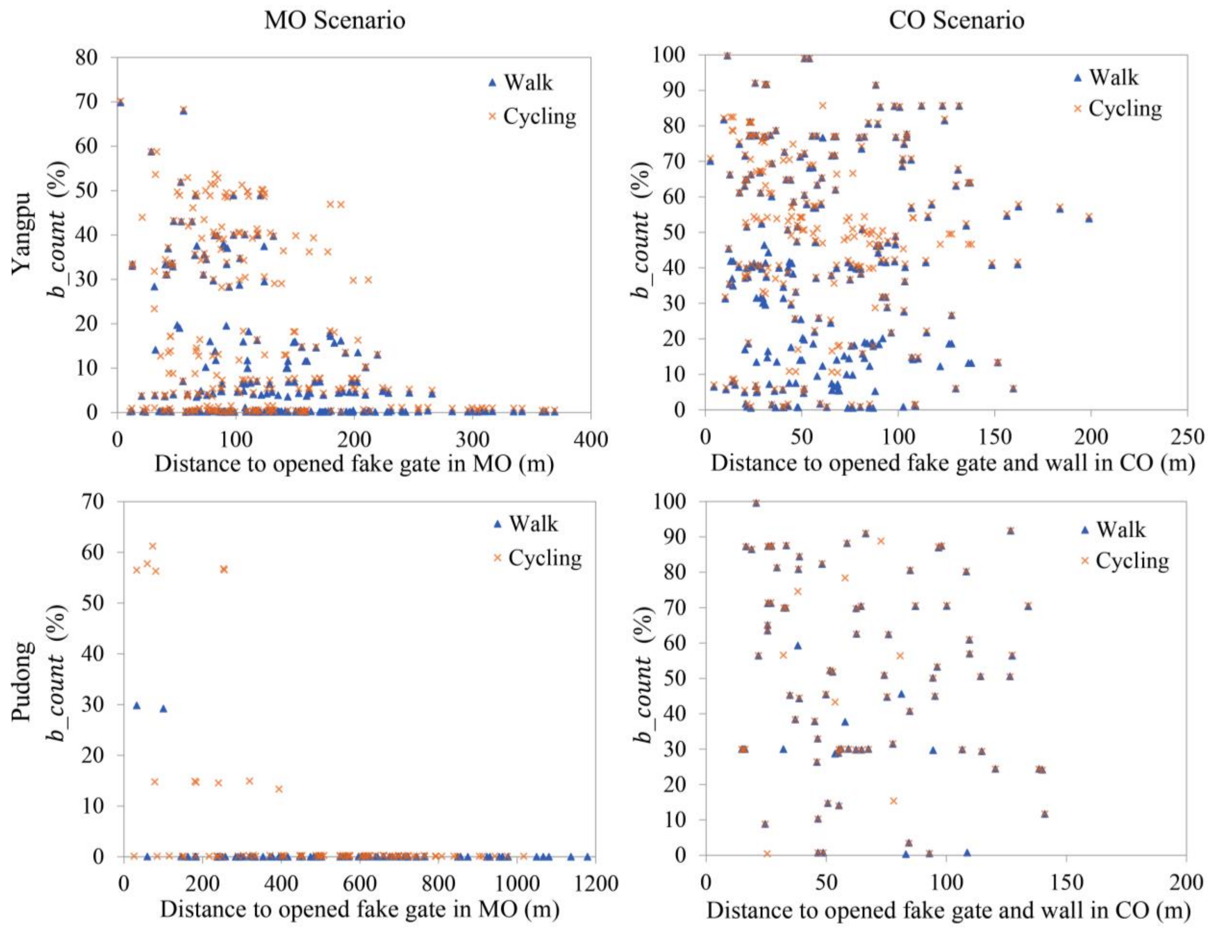

Figure 4. Residence locations against accessibility benefits in two scenarios.

Figure 5 depicts the effect of the second factor, whether the location of a residential building is marginal or central. Firstly, residents who live in more central areas generally gain less benefit in the MO scenario than the CO scenario. This is natural: as shown in Figure 2, opening the fake gates has little influence on O1 to D4. However, the route O1-D4 will be significantly shortened when the walls are broken down in the CO scenario. On the contrary, residents who live nearby the edge have greater chances to improve their accessibilities in the MO scenario. Such a phenomenon can be seen in many blocks of both Yangpu and Pudong cases in Figure 5. Secondly, those living nearby the edge and more adjacent to the wall benefit the most in the CO scenario. In Figure 5, the northwest block in

Yangpu and the southern three blocks in Pudong are the best examples. This is because many trips of those living nearby the edge, such as O2-D2 and O4-D3 in Figure 2, are naturally more limited by the walls. Therefore, when gates are added by breaking down the wall in CO scenario, they benefit significantly.

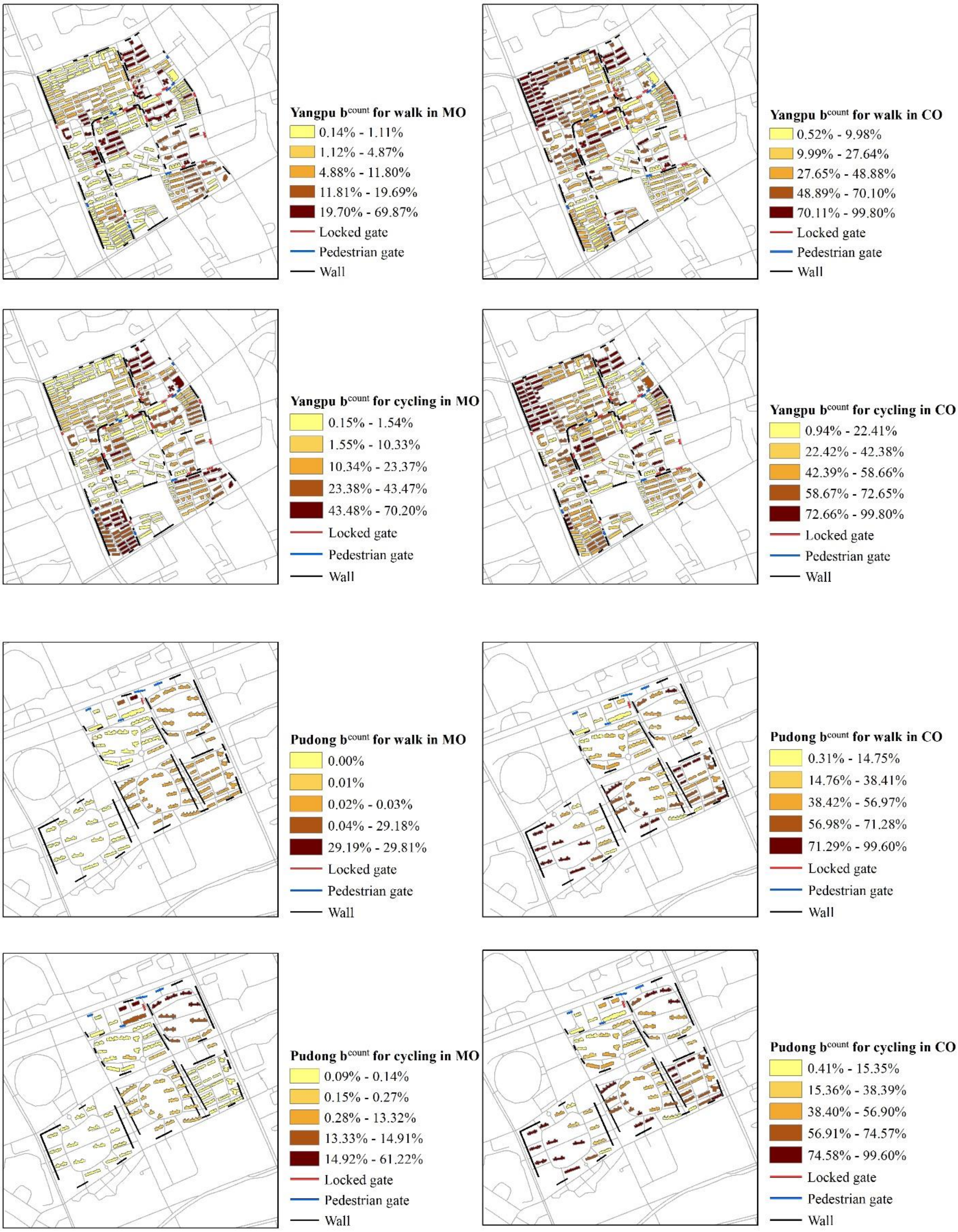

Figure 5. Spatial heterogeneity of b^{count}.

4.4 Potential risk analyses

This section analyzes the potential penetrating risk due to opening new gates. Since nearby citizens tend to cross the community for travel convenience, security and living environment inside the community may be adversely affected. To measure such risk, it is assumed that if trip originates from the buildings that outside but within the neighboring 500m of the case communities receives an accessibility gain larger than 50m, it is considered likely to penetrate the community. Then, we propose another metric $risk^{count}$, which measures the proportion of such trips from outside the community.

The result shows that the penetrating risk is relatively marginal and far less than both our expectation and the reward. Compared to the overall benefits in Table 2, where 9-17% of the internal ODs have their distances reduced more than 50m, Table 4 presents only 1% of external ODs may penetrate. In the CO scenario, although the $risk^{count}$ reaches 5-7%, benefitted internal ODs increase to 40-50%. Again, the risk is far less than the reward. Actually, penetrating risks can be mitigated by detailed road and landscape design. For example, if roads within the community are joined to external urban arteries through twisted other than a direct connection, it will be hard for outsiders who are unfamiliar with the community to see through and take shortcuts because of obscured vision.

Table 4. Potential risks from crossing traffic.

	Yangpu		Pudong	
	walk	**cycling**	**walk**	**cycling**
MO>50m	0.84%	1.25%	0.06%	0.51%
CO>50m	4.68%	5.64%	7.10%	7.19%

5. Conclusions and discussions

Taking two typical GCs in Shanghai as examples, this study quantifies and analyzes the accessibility benefits of opening gated communities. Considering more realistic factors, the accessibility benefits are quantified in two opening scenarios with respect to four categories of facilities and for both pedestrians and cyclists. Quantitative analysis is carried out combining activity models and the data from Comprehensive Transportation Survey, census data, and online mapping services. Major findings are,

(1) Opening GCs can indeed bring sufficiently perceptible accessibility. In MO and CO scenarios, up to 17% and 52% of the residents could experience accessibility gains exceed 50m, respectively.

(2) Cycling benefits more than walking in all cases and all opening GCs scenarios, which can be attributed to the pedestrian gates. Considering the wide distribution of such gates in China, to open may be essential for creating a bicycle-friendly environment.

(3) The types of GCs and facilities matter. Compared to the conventional GCs that derived from working units, the newly established modern GCs in Shanghai may have fewer benefits in MO but more in CO. In terms of different facilities, the bus station demonstrates the largest accessibility gains while the metro station polarizes between the two cases, which is probably due to their spatial distribution.

(4) The locations of residential buildings also matter. The accessibility benefit of a residential building is highly determined by their closeness to the corresponding opened gates and their relative location in the block. However, complete opening (CO) can erase the spatial heterogeneity, though at great expense.

(5) In MO and CO scenarios, only 1% and 5-7% of external ODs may penetrate, respectively. The risk is far less than both our expectations and the reward.

The findings in this study put forward at least two policy implications for opening GCs in China. Firstly, it proposes strong support for opening GCs considering the significant overall benefits,

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comparatively low risk, and stable accessibility benefits in terms of metro/bus stations, which may further improve the utilization of public transit in Shanghai. Secondly, the result suggests that we need GC-specific policies rather than general opening policies since communities have dramatically different benefits in different opening scenarios. In spite of this, we strongly recommend that pedestrian gates in Shanghai should be opened before any radical policies are implemented.

Moreover, opening GCs could have more side effects than measured in this paper. For instance, to mitigate existing transportation conflicts, the key point is not merely the openness of GCs but rational urban traffic plan. An advanced road network planning should synthetically increase its capacity for both cyclists and pedestrians. Second, accompanied by the opening-up, the allocation of public resources becomes the primary issue. Government finances are already tight in many parts of China, indicating that a radical change in the pricing model for public services will be inevitable to follow the international open block system. The prosperity of community public life can be realized only after the property right, privacy, convenience, and sharing of public facilities acquire guarantees.

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Conflicts of Interest:

The authors declare no conflict of interest.

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