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Invisible walls: Measuring the impact of organized violence on urban expansion

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ABSTRACT

In this paper, we examine the relationship between built-up area residential density and organized violence. Security for most of human history has been one of the driving factors for city development and growth; this remains true today. What is new, is that the prevalence of organized violence is associated with increased population density in adjacent built-up areas. Throughout history, those fleeing organized violence have sought refuge in areas that provided "pockets of safety" or a measure of "relative security." We first observed this phenomenon in Colombia when we found that after decades of organized violence between guerilla groups and the Colombian national government, its cities were denser than cities in neighboring countries. Drawing on data from the Uppsala Conflict Data Program, we found that in a representative sample of 200 global cities, cities with frequent organized violence were also associated with denser residential built-up areas as well. We conclude that organized violence creates an invisible wall that contains the outward expansion of cities adjacent to organized conflict.

1. Introduction

Cities have always been places of refuge and commerce (Childe, 1950, Mumford, 1968, Wu & Gaubatz, 2013). Cities enabled individuals and groups to break away from small, kinship-based, rural communities, and live in close proximity to others at higher densities (Wirth, 1938). The collocation of large numbers of people and job opportunities allowed for increased inventiveness and greater productivity (Jacobs, 1969). The social experiment of the city, the clustering together of strangers, thrived, in part, because of the perception of safety and certainty that came with urban living. Early cities created the perception of safety by marking their territory through the construction of walls. Sack (1986, p.19; emphasis in the original) defines this act of territoriality as, "*the attempt by an individual or group to affect, influence, or control people, phenomena, and relationships, by delimiting and asserting control over a geographic area.*" While the act of establishing territory can happen at multiple scales, from the rooms in a home to a nation's borders, this paper focuses on cities and urbanized areas.

While the establishment of city walls and later national boundaries catalyzed urban and metropolitan development, especially in Europe after the Peace of Westphalia in 1648, there are important caveats to this narrative of expansion and peace (Brenner, 2004). When nations failed to secure their national borders or if internal rivals challenged ruling parties, cities became places marked by civil strife (Beauregard, 2018, pp. 120–151). Furthermore, concerns about street crime or urban violence–a topic beyond the scope of this paper–have also been shown to affect population growth (Cullen & Levitt, 1999; Buhaug & Urdal, 2013). Thus, just because a ruler or regime establishes a territory at one point in time doesn't guarantee that the territory will stay the same size, remain under the same leadership, or persist into the future. Fixing the boundaries of a city or state is an ongoing process.

In this paper, we argue that the concept of "relative security," the safety of the city versus its outlying area or vice-versa, still plays a critical role in determining the built-up area and population density of cities even after the custom of constructing city walls has disappeared. The implication of this hypothesis is critical to planning: in nations transitioning from ongoing civil wars to peace, we expect cities in those nations to see continuous reductions in built-up area population density and greater utilization of land, even if recent data in those nations suggest the opposite. This suggests that these countries will see the built-up area of their cities expand much more rapidly than in previous periods. This supposition impacts the provision and demand of housing, infrastructure, and transportation policy directly.

We developed this theory after examining data from over 100 Colombian cities and then expanding our research to 200 cities around the world. Since this research started in Colombia, we began our literature review by examining the impact of violence on Colombia's cities. As our hypothesis gained more credence, we reviewed the broad

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literature on urbanization and violence to understand the multiple dimensions of violence and establish a relationship between "relative security" and urban form. While Colombia has been embroiled in multiple civil conflicts since the 1800s, we are most interested in the period between 1989 and 2015. We selected these years because they coincide with the rise of *Fuerzas Armadas Revolucionarias de Colombia* (FARC), the guerilla group, and the peace negotiation between the Colombian state and FARC in 2016.

We collected and analyzed two types of empirical data to evaluate the relationship between relative security and density: first, we drew on comparative spatial data on built-up area population densities from a sample of 200 cities from across the world and for 109 Colombian cities. Second, we combined this spatial data with data on conflicts. We ran linear regressions to test the relationship between organized violence and density. We examined densities and built-up areas in Colombian cities and then applied the same method to our global data. We also calculated a synthetic "conflict score" to compare the number of events across cities in our study. We found that organized violence on the urban periphery of all cities acts as an invisible wall by driving densities higher and restraining urban expansion.

In the next section, we examine the background on violence and urbanization, and examine how organized violence has impacted Colombia, specifically between 1989 and 2015. In Section III, we outline our methods before presenting our findings in Section IV. In Section V we close with some thoughts on the implications of this study for the future of cities.

2. Literature review

2.1. Understanding violence

The terms violence, conflict, and insecurity are often used interchangeably and imprecisely. In order to avoid confusion, we decided to define our terms systematically. The first classification scheme we examined distinguished between sovereign, civil, and civic conflict. Beall, Goodfellow, and Rodgers (2013) define sovereign conflict as conflict between nations, such as a war between countries. Civil conflict refers to conflict between organized groups within a nation with the explicit goal of reconfiguring power relations, such as a conflict between a separatist group and a national government. Civic and civil conflict often overlap, but civic conflict refers to violence that responds to state failures, such as a riot after raising bus fares, that may eventually reconfigure power relations but is not motivated by the desire to do so.

In a similar spirit of thinking about violence systematically, the second classification we examined, the Uppsala Conflict Data Program, uses the terms state-based armed conflict, non-state conflict, and one-sided violence to break down organized violence into more nuanced groupings. State-based armed conflict implies that a state military is one of the parties involved in the conflict. Non-state conflict, as its name suggests, accounts for violence between different groups. Melander, Pettersson, and Themnér, 2016, p.728) describe non-state conflicts as fights between established rebel groups and militias, as well as "conflicts between informally organized groups, notably between groups with common identification along ethnic, clan, religious, national, or tribal lines." One-sided violence, on the other hand, is when civilians rather than a group of combatants are targeted by a state's army, militia, terrorist cell, or other organized group.

When we use the term organized violence in this paper, we refer specifically to acts of violence that are perpetrated by or representative of a group with the intention of changing the political order. As a result, scale matters for our study: muggings, or urban violence at the micro-scale, and acts of war that involve two sovereign nations, or conflict at the macro-scale, do not factor into our analysis. Within the broader literature there are multiple studies that look at a single case to generalize from and larger quantitative studies that examine multiple cases. In this study we rely on large data sets to better understand the relationship between population density and organized violence in Colombia and globally; however, much of the individual case studies, help us contextualize the themes examined.

The rich literature on civil conflicts that examine individual case studies show that the search for relative security is theoretical driver of build-up area population density in areas adjacent to organized violence. Beall et al. (2013, p. 3069) capture the dynamic role that cities play in this quest for relative security when they argue that "cities sometimes serve as places of refuge or relative security during conflict and can become economic hubs in war economies, but they may also become sites of insurgency and combat…" Throughout history we find multiple examples, from Russia to China to Nicaragua, that lend credence to the idea that cities' relationship to organized violence oscillates from a site of refuge at one extreme to a site of insurgency at the other (Koenker, 1985, Beall, 2007, Greenspan, 2014, Grescoe, 2016).

For those seeking out safety, the city is a logical landing spot because it provides anonymity and the potential of reinvention. Steele (2009, p. 420) argues that during civil conflict in Colombia dating back to the 1990s, residents who held allegiances with the losing side in the countryside were often left with a handful of options if they wanted to survive, "they could either move to a rival group's stronghold, cluster with others similarly targeted, or seek anonymity in a city or different region." The decision to migrate or remain depends on the dynamic of the conflict and who holds power. In Colombia, however, Steele asserts that "because the main cleavage of the war is not ascriptive, civilians have a third option: they can try to establish anonymity in larger communities" (426). Thus, when combatants or the sympathies of residents cannot be assumed based on outward markers, such as skin color or religious dress, cities are ideal places to blend in and avoid the perils of rural conflict.

In this paper, we focus on the relationship between organized violence and relative security and its impact on density and urban form. We hypothesize that organized violence inhibits the expansion of the built-up area: neither cities nor villages will expand into active war zones. This limits the outward growth of the city or outlying village. Simultaneously, we expect that as these areas are perceived as safer than other areas, they will attract people from areas plagued by organized violence. The desire to remain safe reduces travel between the city and its surrounding outer-suburbs or countryside. This "transportation risk" and fear of what is beyond the zone of relative security erects the invisible wall that circumscribes cities. Glaeser & Shapiro (2002, p.211) observe that "If homes behind city walls create a safe harbor, then travel creates exposure to danger."

Cities represent safety and opportunity when civil unrest is concentrated in the countryside. Gulu, Uganda served as an island of relative security and economic opportunity as a twenty-year civil war displaced Ugandans living in the northern part of the country. Branch (2013, p.3155) describes Gulu as "a centre for forced displacement and voluntary flight by the peasantry during peak times of violence because of the relative security it enjoyed." Even in the middle of a devastating conflict, Ugandans fled the countryside in search of safety in Gulu that was relatively safer. Beall et al. (2013, p.3071) argue that "counter-intuitively, rapid urbanisation and urban stability often go hand-in-hand when a civil war is raging nearby." The case of Gulu perfectly illustrates that the desire for relative security leads to a greater clustering of people, even if the area is adjacent to organized violence. Furthermore, while cities can be the site of organized violence, in the case of Gulu and other conflicts, cities were seen as areas of relative security despite the strain of rapid, unplanned urbanization.

Moving beyond individual case studies, we also examined broader studies that compiled data from across the globe. In each of these cases, the primary goal is to understand the determinants of conflict rather than understand changes to urban form. As such, cities are part of a broader selection of variables that help explain the determinants of conflict such as economic development, regime stability, ethnic composition, authoritarianism, etc. When cities, or more specifically the

rate of urbanization, are considered, these scholars aggregate data from all of the cities in a country rather than differentiating between them (Auhvinen, 1997; Urdal, 2005). Our argument differs from these studies because we are interested in individual cities because location matters. So even in nation's experiencing sustained civil conflict, individual cities or outlying areas will show greater levels of population density because people are searching for relative security within the country, just like in the example of Gulu, Uganda.

Buhaug and Urdal (2013) looked at violence independent of scale to see how it relates to population growth. Population growth and population density are not the same, but the underlying theory that these authors are testing is that in fast growing cities, especially in countries with few resources and jobs to absorb migrants, violence is more likely to take root. They concluded, however, that "there is little evidence to suggest that higher population growth rates are associated with more political violence" (Buhaug and Urdal, 2013, p.6). While this finding is not perfectly analogous to our study, it dovetails with our more general claim about the search for relative security leads to greater population density. In interpreting their analysis they make sense of the lack of association between population growth and violence by affirming the conceptual set up of this paper: "In principle, this lack of association could be the result of an endogenous relationship between urban population growth and violence whereby rural residents refrain from moving to the city when it is considered unsafe" (Buhaug and Urdal, 2013, p.7). Thus, when the city is unsafe, rural migrants stay in place and perhaps urban residents flee to countryside. Auhvinen (1997) and Finer (2017) advance the theory that cities and urbanization have a dampening effect on coups and military action because of the development of a strong civic culture. While these two theories run counter to one another when thinking about where unrest is more likely to break out, they conform to the idea that people avoid conflict whether in cities or outlying areas and cluster in locations that are relatively safer.

2.2. Organized violence in Latin America and the Caribbean

Over the last 50 years, state-based armed conflict in Latin America and the Caribbean has been concentrated in the countryside rather than in cities. Following the successful models of China and later Cuba, rebel forces and revolutionary movements looking to seize national political power organized their bases outside of cities to consolidate support among the rural population before launching attacks on major cities. As the countryside became more dangerous, civilians fled to cities. Rodgers (2009) asserts that intense state-based armed conflict in the countryside of Nicaragua, Guatemala, and El Salvador catalyzed urbanization. In Nicaragua, Rodgers found that the Contra war was "principally a rural conflict," because the Contras "were never in a position to directly affect major urban centres" (p.952). The Contras did, however, make the Nicaraguan countryside inhospitable, forcing Nicaraguans to flee and cluster in nearby cities.

We argue that sustained organized violence rather than singular events are key to driving people in and out of cities. When people need to balance the survival of their families against higher incomes, better housing, amenities, or quality of life, they choose survival. One-time events, such as September 11th or recent bombings in Paris and London have delivered dramatic shocks to each city, but have failed to derail longer-term prospects for growth and prosperity (Bram, Haughwout, & James, 2002). Indeed, the frequency of violent events is more relevant than the scale of a one-time event in deciding where and how to live. Kahneman and Tversky's (2013) "Prospect Theory" advances the notion that when people make decisions under duress they make decisions that are perceived to be certain rather than speculative. In other words, if an event occurs often, even at a small scale, it affects the decision to act more than the expectation of a large-scale event that is less likely to occur.

3. The Colombian story

Organized violence in Colombia is as old as its history (Pardo, 2004). The nature of this violence—whether involving the pre-colonial struggles, the revolutionary wars, the civil wars, or the modern day war against drug cartels—may have changed, but it has always been present. Organized violence had not been documented as a primary force propelling rural-urban migration until *La Violencia* in the 1950s (Lozano-Garcia, Piras, Maria Ibáñez, & Hewings, 2010). Schultz (1971, p.159) found that "the search for physical security from the violence that raged in many areas of rural Colombia during the 1950's" was one of the three main drivers of rural-urban migration.

Despite the negotiated peace agreement between the Liberal and Conservative political parties in 1958 that ended *La Violencia*, organized violence has continued to be a persistent problem in Colombia. Since 1989, the Colombian government has negotiated 10 different peace treaties with guerilla armies, paramilitary groups, and others seeking to challenge or reorganize the Colombian State. Ibáñez and Vélez (2008) explain that as anti-government groups gained financial strength through the 1980s with income from drug sales, they expanded their offensive and ratcheted up the intensity of civil conflict across the country. As in other countries in Latin America and the Caribbean, the locus of skirmishes and violent incidents tended to be in the countryside rather than in cities:

> Although the main goal of these groups was to overthrow the democratically elected government, their strength was limited; thus, their actions were targeted only to distant rural areas. The balance of power changed when illicit drug trade consolidated in Colombia during the early eighties. By providing financial resources to illegal armed groups, drug trade fueled the conflict and allowed its geographical expansion. In addition, drug barons and some large landowners in rural areas created paramilitary groups in the 1980s to protect economic interests and mitigate attacks from guerilla groups. All these factors escalated violence against the civil population. (Ibáñez & Vélez, 2008, p.660)

The outcome of sustained civil conflict displaced no fewer than 7.7 million Colombians (United Nations High Commission on Refugees, 2018, p.6). Not all victims of Colombia's civil conflict, however, were displaced. Many chose to remain in their communities. Steele (2009, p.426) explains that depending on where one lives determines which strategies one employs in order to remain alive:

> whether a community is rural or urban should change households' calculations for how best to reduce the likelihood of suffering violence. Cities as large as Bogota or Medellin may be able to hold many enclaves, and either moving to a stronghold or an armed group or clustering with others may mean moving across town. Rural communities, in contrast, are likely to become an enclave unto themselves. Clustering with others in rural communities may not sufficiently decrease the odds that one's family will be directly affected by violence.

In areas overwhelmed by civil conflict, victims found safety by both fleeing to bigger cities and by gathering into enclaves in rural areas. The act of clustering, both in cities and in the countryside, has led to higher built-up population densities in cities and in rural towns.

It comes as no surprise, therefore, that Colombia offers fertile ground for investigating the relationships between civil conflict and population density. In fact, the impetus for this study was our realization that the average population density of Bogotá, the capital of Colombia, was far greater than expected. When we examined data from 200 cities in the *Atlas of Urban Expansion—2016 Edition* and 109 Colombian cities in the *Colombian Atlas of Urban Expansion*, we found that the average population density within Bogotá's built-up area was 221 Persons per Hectare (PpH) in 2015. In Latin America and the Caribbean, the average density within the built-up area of cities in the

sample was 75 PpH. When we looked at all 200 cities in the global sample, the average density within the built-up area of all of 200 cities was 84 PpH.

As we explored Bogotá's built-up area population density versus other cities in the global sample, we found that 90 percent of Bogotá's population growth between 1989 and 2015 occurred in areas of the city that were already developed in 1990; thus, there was little urban expansion despite an almost doubling of population from 4,438,705 to 8,062,610 (Fig. 1).

This finding, like the initial density finding, raised more questions. When we compared population growth in cities like Baku, Madrid, and Cairo, we found that those cities added modest amounts of population within the existing urbanized area before 1990 and saw much greater population growth in undeveloped areas. In Madrid, for instance, 80 percent of its population growth between 1991 and 2010 occurred beyond the developed areas of the city (Fig. 2). Even when we compared Bogotá to cities with much greater rates of population growth within areas of the city occupied before 1990, we found that cities like Bangkok and Dhaka only added 55 and 54 percent, respectively, of its population growth in these areas.

Bogotá's growth was much more compact than any of the other cities in the smaller sample of 10 cities that we examined.[1] As can be seen in Fig. 3, it is as if an invisible wall surrounded Bogotá and prevented its outward expansion, as only 10 percent of the population growth between 1990 and 2015 settled in the area beyond the 1990 built-up area.

This exploration of average densities raised a key question: Why is Bogotá's density so much greater than those of the neighboring cities in its region? When we looked at other cities in Colombia, we found a similar trend of hyper-density that surpassed any world averages: small towns near conflict were often times very dense, such as Cumaribo 528 PpH, Puerto Guzman 436 PpH, and Sucre 422 PpH. This trend also held true for other large cities, like Medellin 184 PpH, Pereira 160 PpH, and Buenaventura 216 PpH. Colombian cities were 100 percent denser than the world average and 126 percent denser than the Latin America average (Table 1). This led us to theorize that the presence of persistent civil conflict in Colombia helps explain why Colombian cities are so much denser than other cities. Despite the greater density of Colombian cities on average versus other countries, Colombian cities have become less dense since 1990. Later in the paper, we will look specifically at Colombian cities adjacent to civil conflict.

4. Methodology and data

We investigated the relationship between relative security and density by collecting comparative spatial data from around the world and combining it with georeferenced data on organized violence. We used regression analysis to test the relationship between population size, Gross Domestic Product per Capita Purchasing Power Parity, relative security, and built-up area density.

We examined two sets of comparative spatial data to carry out our analysis. First, we turned to the *Atlas of Urban Expansion—2016 Edition* to gather baseline data on density and built-up areas in a global sample of 200 cities (Fig. 4). These cities form a representative sample of the universe of cities with populations greater than 100,000 inhabitants in 2010. The *Atlas* uses unique definitions for what constitutes a city so that its data can be used to compare across cities. Instead of measuring activity within the municipal boundaries of cities, it measures activity within the built-up area. The built-up area denotes the contiguous built-up area that approximates a city's metropolitan area minus open space (Angel et al., 2016). This means that the built-up area of some cities may combine multiple municipalities into one built-up area, such as a metropolitan region.[2] This distinction is especially useful for this type of analysis because it provides a truer sense of what is adjacent to conflict and what is separate and distinct. The second set of comparative spatial data we relied on was the *Colombian Atlas of Urban Expansion* (Fig. 5). This dataset was constructed in the same fashion as the *Atlas of Urban Expansion*, but instead cataloged spatial data for 109 Colombian cities.

The next step we undertook in our data collection efforts was to combine this spatial data with data on conflicts. We used the UCDP dataset on conflicts dating back to 1975. Since our spatial data was collected at three time periods, approximately 1990, 2000, and 2015, we only used data from UCDP going back to 2000 so that our datasets were temporally matched.[3] The UCDP does georeference events, but it uses a single centroid per city rather than the precise latitudes and longitudes to mark where each event occurred. Thus, all events in Bogotá were geolocated to one generic centroid rather than spread across the city. In trying to theorize an appropriate geography to include in our relative security measure, we chose to draw a buffer of 50 km. We settled on 50 km because when we estimated walking speeds, from 4.3 km/h for adults to 3.2 km/h for older people and younger. Thus, when estimating how far a two-day walk would take someone or a family, we assumed that adults, children, and the elderly could make it 50 km over two days (Fitzpatrick, Brewer, & Turner, 2006). While this measure is a rough approximation, we argue that a two-day walk represents the minimum distance one will go in search of relative security.[4]

With all of our data collected, we performed two sets of analysis to investigate our question: Does organized violence influence built-up area population density? First, we developed a synthetic "conflict score" to compare the number of conflicts across cities and regions in the dataset. This amounted to summing the total number of events within each city between 2000 and 2015. Once we added up all of the incidents in each geography, we ranked the cities by number of conflicts.

Second, we carried out linear regressions to understand what drives density in Colombian cities. According to Angel, Parent, Civico, and Blei, 2011; 2018) the two main drivers of population density are population and GDP per capita PPP. The theory holds that as city residents increase their GDP per capita PPP, they consume more space and density declines because fewer people occupy each unit of space. Conversely, as population increases, outward expansion slows as rates of residential density increase. In other words, all else being equal, richer cities are less dense than poor ones and more populous cities are denser than less populous ones. When we tested this theory using spatial and population data from the *Atlases* and economic data from the World Bank, neither variable explained the hyper-density of Colombian cities.

5. Results

5.1. Initial findings

The first regression we ran used data from the global sample of 200 cities where built-up area density was the dependent variable and built-up area population and GDP per capita PPP were independent variables. We found that, on average, for every 10 percent increase in population there was a 3 percent increase in density and for every 10

[1] This smaller sub-sample of cities is illustrative rather than definitive. We have not yet collected this data for all 200 cities so this dataset is not representative of the larger universe of cities.

[2] For more on the process of determining built-up areas using satellite imagery see Blei et al. (2018).

[3] Sometimes data is from 1989 or 2014 or another year that is close to 1990, 2000, or 2015.

[4] The process of establishing this boundary was guided by basic principles, but relies on arbitrary rules of thumb rather than observed data.

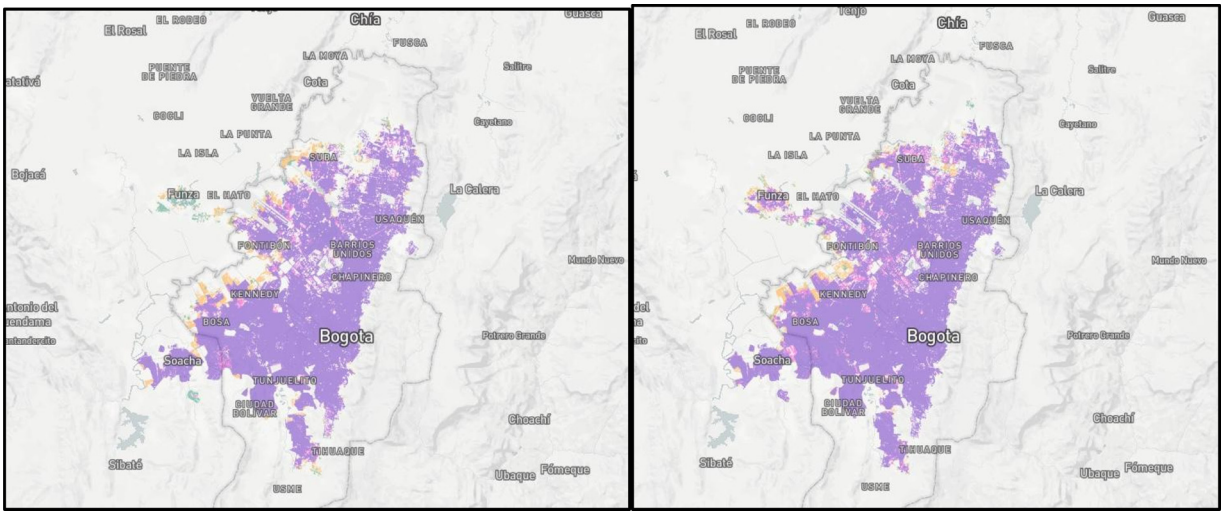

Fig. 1. Bogotá's built-up area 2003 (left) and its built-up area in 2015 (right). (Colombian Atlas of Urban Expansion).

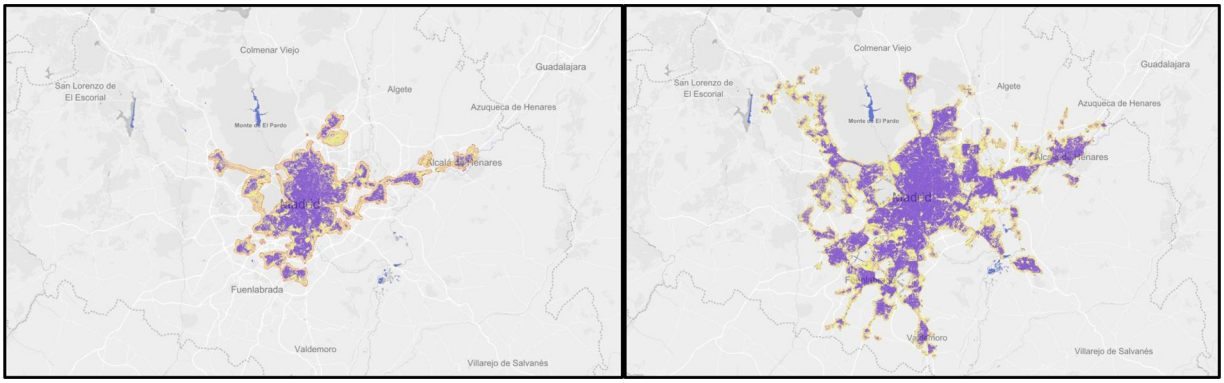

Fig. 2. Madrid's built-up area 1991 (left) and its built-up area in 2010 (right). (Atlas of Urban Expansion).

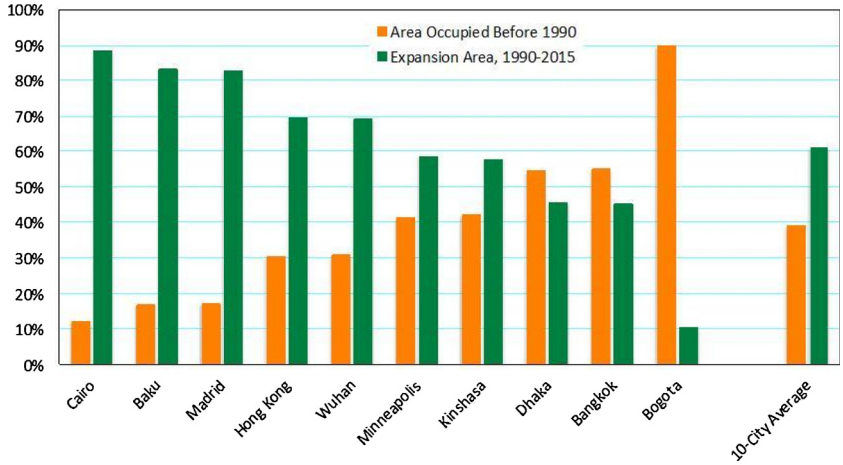

Fig. 3. The share of added population between 1990–2015 that was accommodated in areas developed before 1990 against the expansion areas developed between 1990–2015. (Authors' own calculations).

percent increase in GDP per capita PPP there was a 7 percent decrease in density. Thus, these independent variables confirmed what we found in the literature: as population increases, density increases, and as GDP per capita PPP increases, density decreases.

While these results made sense for our sample of 200 cities, they failed to explain what we observed in Colombia. Colombia's GDP per capita PPP in 2015 was $13,825, 11.8 percent below the global average of $15,675 (World Bank, 2019). This lower GDP per capita PPP indicates that Colombian cities should be denser on average, which they were. The weights from analysis, however, predicted that they would be 8.26 percent denser. The observed difference was much higher. Colombian cities were 100 percent denser than cities around the world.

After exploring GDP per capita PPP in Colombia versus the output from the regression, we examined the population data to see if that provided a closer approximation of the observed data. First, we had to account for the fact that the *Atlas of Urban Expansion–2016 Edition* only

Table 1
Average built-up area density with confidence interval of Bogotá and Colombian cities compared to regional averages for the world circa 2014. (Atlas of Urban Expansion–2016 Edition and Colombian Atlas of Urban Expansion).

City and Region	N	1990	2000	Circa 2014
Bogota	1	181	223	221
Colombia	20	195 [180.6–210.2]	180 [162.2–197.8]	170 [152.3–187.9]
Latin America and the Caribbean	26	95 [71.4–119.5]	78 [62.8–92.2]	75 [59.6–91.0]
Less Developed	148	207 [176.8–237.1]	150 [131.8–167.8]	102 [91.5–112.0]
Europe & Japan	34	64 [54.5–73.7]	48 [41.2–55.1]	39 [34.5–42.7]
Land-Rich Developed Countries	18	25 [21.5–29.0]	21 [17.9–23.3]	19 [16.7–22.1]
World	200	166 [141.9–190.3]	121 [105.8–135.7]	84 [74.9–92.3]

This proved to be a productive path of inquiry.

When we organized the 109 cities in the *Colombian Atlas* into PDET and non-PDET municipalities, we found that 21 of them were PDET and 88 were non-PDET municipalities (Fig. 6). In 2014, The PDET municipalities had 224 PpH while non-PDET municipalities had 160 PpH (Table 2). In other words, PDET municipalities associated with intense conflict were 40 percent denser than the rest of the sample. Furthermore, the relationship between built-up area density in PDET versus non-PDET cities followed different trends over time, suggesting that the waxing and waning of violence may have had disparate impacts in cities across the country. Between 1990 and 2015, the Non-PDET cities see a steady decline in built-up area population density. In the PDET cities, on the other hand, the trend is much less clear, a large decline in population density between 1990 and 2000 followed by a dramatic upswing between 2000 and 2015. We confirmed the statistical significance of this result by running a two-sample t-test.

To better examine the relationship between urban density and other

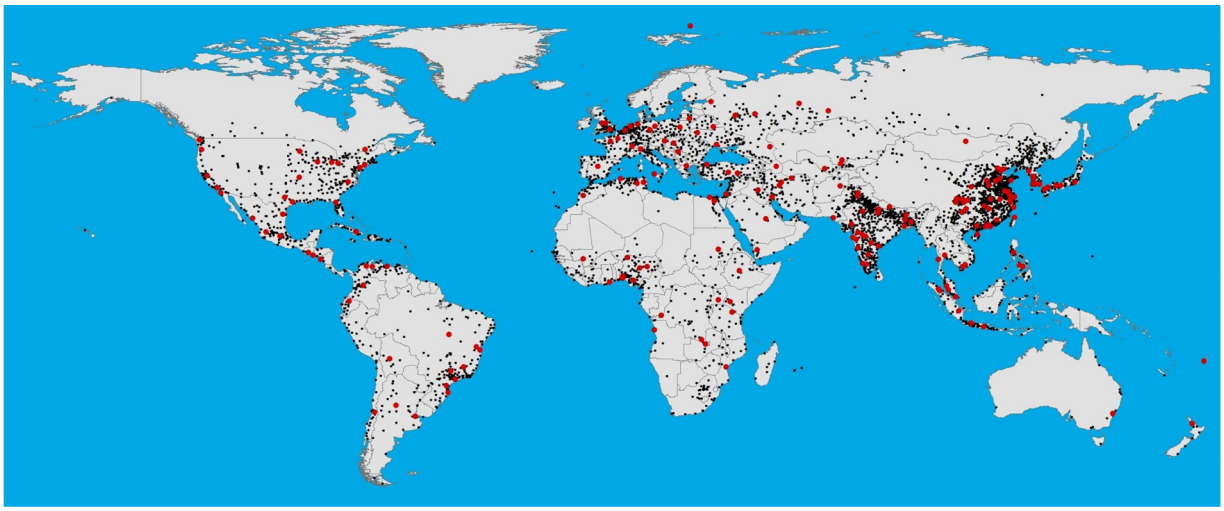

Fig. 4. The universe of 4231 cities in the world that had 100,000 people or more in 2010 and the global sample of 200 cities.

includes cities with populations greater than 100,000. In order to remain consistent and compare like cities, we initially focused on Colombian cities with populations greater than 100,000 in the *Colombian Atlas of Urban Expansion*. There were 18 Colombian cities with populations greater than 100,000 with an average population size of 1.1 million, and a median of 361,000. When we compared these results against the average and median populations in the global sample of 200 cities, we found that the average population per city was 706,000 with a median of 299,000. Thus, based on the model, it was expected that Colombian cities would be 16.33 percent denser than the global average. Once again, Colombian cities were 100 percent denser; thus, neither GDP per capita PPP nor population, explained the observed hyper-density in Colombian cities.

5.2. Operationalizing relative security in Colombian cities

Since neither population nor GDP per capita PPP explained hyper-density in Colombian cities adequately, we hypothesized that the prevalence of organized violence played a key role in driving higher rates of density. To test this hypothesis, we examined the 169 of 1121 Colombian municipalities that were included in the 2016 Teatro Colon peace agreement between the FARC and Colombian government. These cities were selected by the Colombian government and FARC as being the main cities affected by the conflict and in need of additional resources to catalyze development through *Planes de Desarrollo con Enfoque Territorial* "PDET" (Development Plans with Regional Focus).

variables, we applied an ordinary least squares regression using log density as the dependent variable. We included log population as an independent variable to control for the effect that cities with greater populations are denser, on average. If a hypothetical non-PDET city became a PDET city, we would expect it to be 68 percent denser (*Exp* (0.52)-1 = 68 percent) (Table 3).

This finding, that PDET municipalities are denser than non-PDET municipalities, was the first piece of evidence that suggested that relative security may help explain why Colombian cities are among the densest in the world.

5.3. Conflict score: cities in Colombia with higher conflict scores are denser

Since we did not have a list of cities around the world that were carefully selected for the presence of organized violence, like we did in Colombia, we developed a conflict score based on UCDP data to replicate our method in Colombia (Table 4). We tested the soundness of the conflict score methodology by applying it to the Colombian cities. The conflict score methodology results supported our earlier analysis and showed that cities with higher conflict scores were denser than cities with lower conflict scores. We found that the distribution of organized violence around municipalities was highly skewed to the right as many cities had zero conflicts. When we stratified the 109 Colombian cities by conflicts, we found that the top-20 percent of cities experienced 1803 incidents of organized violence from 2000 to 2015, 82 incidents of conflict per municipality or 5.45 events per year. Meanwhile,

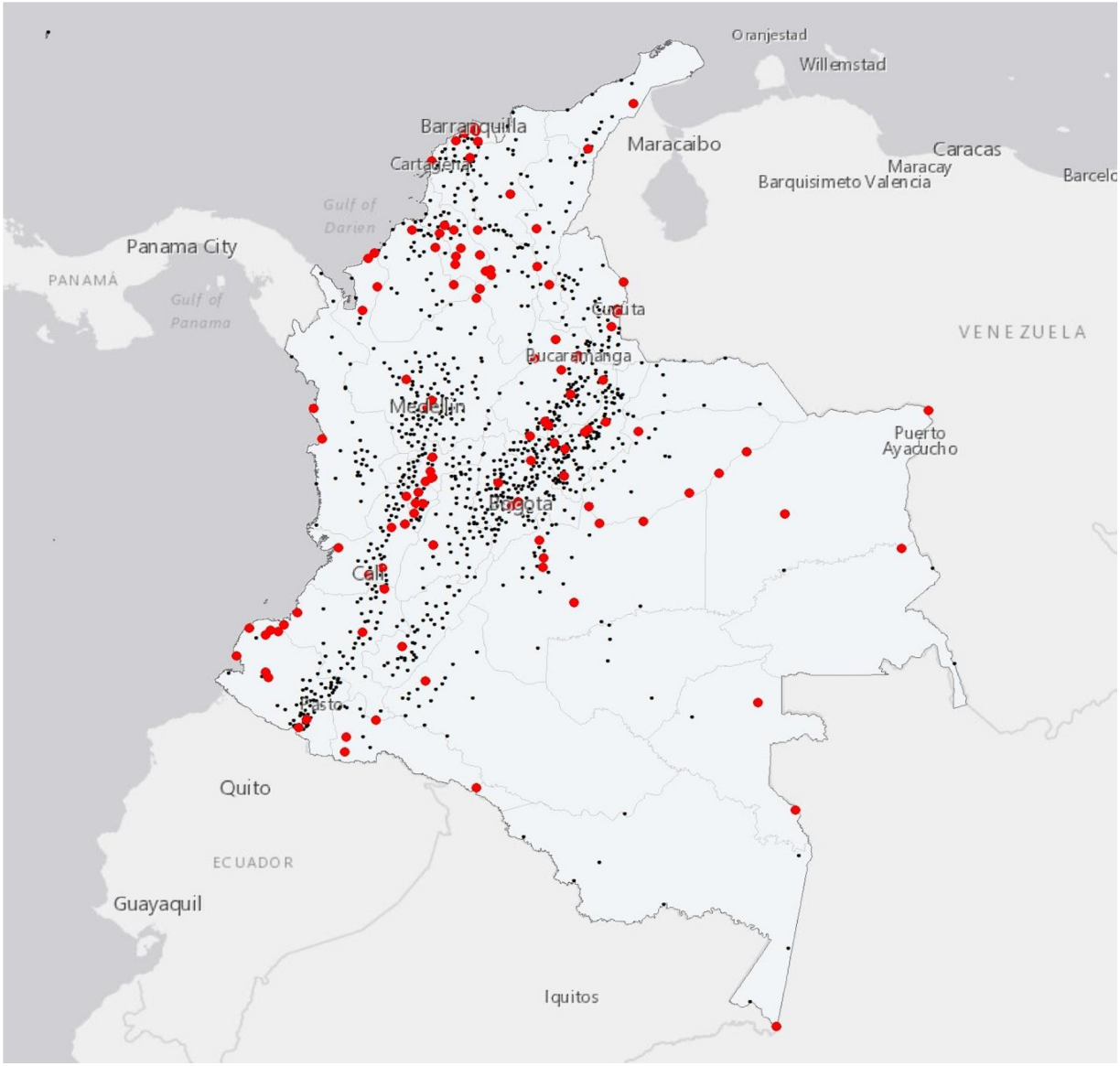

Fig. 5. The universe of 1102 municipalities in Colombia in 2016 and the representative sample of 109 Colombian cities.

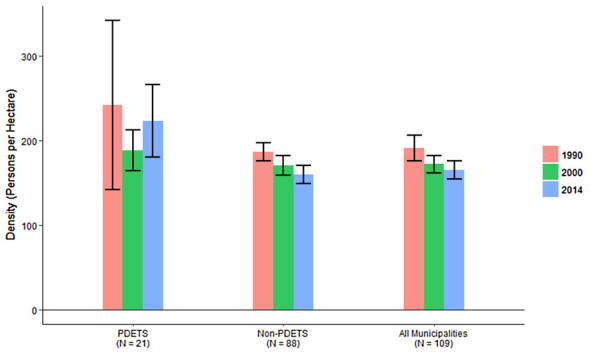

Fig. 6. Average built-up area population density with confidence interval for PDET municipalities compared to non-PDET municipalities in 1990, 2000, and circa 2014. (Colombian Atlas of Urban Expansion).

the rest of the Colombian sample had 1720 incidents over the same time period, 20 incidents of conflict per municipality or 1.31 events per year. Around 2014, the top 20 percent of municipalities ranked by their conflict counts were on average 24 percent denser with an average

Table 2
Average built-up area density with confidence interval for PDET municipalities compared to non-PDET municipalities in 1990, 2000, and circa 2014. (Colombian Atlas of Urban Expansion).

Mean [Confidence Interval]	1990	2000	circa 2014
PDETS Municipalities (N = 21)	242.5 [142.4–342.6]	188.5 [164.4–212.5]	223.8 [180.7–266.8]
Non-PDETS Municipalities (N = 88)	186.8 [176.2–197.4]	170.5 [158.7–182.3]	159.8 [149.3–170.2]
All Municipalities (N = 109)	191.3 [176.2–206.3]	172.0 [161.4–182.5]	164.9 [154.1–175.8]

Table 3
Linear Models with log built-up area density in 2015 as the dependent variable in Colombia sample.

Predictor Variable	Coefficient B	Confidence Interval	P-value
Log Population Size	0.09	[0.06, 0.11]	< .0001
PDETS	0.52	[0.30, 0.74]	< .0001

Table 4
Top 10 cities ranked by conflicts score for Colombia and the World. The conflicts scores in the table were calculated based on the Colombian sample of 109 cities, the global sample of 200 cities, and the universe of 4231 cities. (UCDP).

Colombia	Conflicts	Global Sample	Conflicts	Universe of Cities	Conflicts
Cali, Valle Del Cauca	143	Baghdad, Iraq	2137	Srinagar, India	2167
Corinto, Cauca	138	Kabul, Afghanistan	1224	Mogadishu, Somalia	1698
Palmira. Valle Del Cauca	124	Tel Aviv, Israel	773	Gaza, Palestine	1547
Medellin, Antioquia	116	Algiers, Algeria	487	Rafah, Palestine	1540
Popayan, Cauca	108	Pokhara, Nepal	267	Khan Yunis, Palestine	1535
Bogota, Santafe De Bogota D.C.	94	Sialkot, Pakistan	235	Anantnag, India	1520
Salamina, Caldas	89	Karachi, Pakistan	210	Jalalabad, Afghanistan	1440
Puerto Gaitan, Meta	88	Kigali, Rwanda	170	Baghdad, Iraq	1429
Corozal, Sucre	87	Tijuana, Mexico	165	Mosul, Iraq	1368
Florencia, Caqueta	86	Sana, Yemen	147	Beersheba, Israel	1362

Table 5
Average population density with confidence interval of the top 20 percent Colombian cities ranked by conflict score compared to the rest of the cities over period 1990 to circa 2014. (Colombian Atlas of Urban Expansion).

Mean [Confidence Interval]	1990	2000	circa 2014
Top 20 percent of Cities (N = 22)	206.8 [194.1–219.5]	194.7 [182.8–206.6]	180.7 [168.2–193.1]
Rest Cities (N = 87)	172.7 [149.1–196.3]	144.7 [130.3–159.2]	146.1 [130.2–162.0]
All Cities (N = 109)	191.3 [176.2–206.3]	172.0 [161.4–182.5]	164.9 [154.1–175.8]

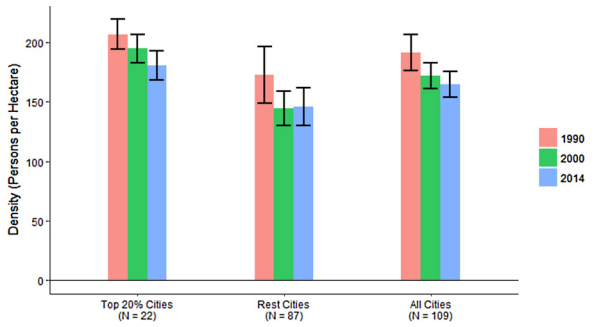

Fig. 7. Average population density with confidence interval of the top 20 percent Colombian cities ranked by conflict score compared to the rest of the cities over period 1990 to circa 2014. (Colombian Atlas of Urban Expansion).

density of 181 PpH compared to 146 PpH in the rest of the sample (Table 5; Fig. 7).

When we controlled for population within Colombian cities, we discovered that the conflict score statistic was a significant predictor for population density. For every 10 percent increase in conflict counts we expect a 1.3 percent increase in density, on average. If a hypothetical city in the bottom 80 percent, as ranked by conflict score became a city in the top 20 percent, we would expect its density to increase by 8 percent (Table 6).

5.4. Cities with high conflict scores are denser in the global sample

When we applied the same methodology and calculated conflict scores for the 200 cities in our global sample we found that the majority of the world was free from organized violence between 2000 and 2015. Of the 200-city sample, 122 cities, or 61 percent of the sample, had experienced no incidents at all. Baghdad, Iraq ranks at the top of 200-city sample with 2137 incidents of organized violence between 2000 and 2015. Only 10 of the 200 cities in our global sample had more than 100 incidents of organized violence during this 15-year period.

Just as we saw that higher conflict scores were associated with higher densities in Colombian cities, the same relationship appeared in the global sample of 200 cities. The 40 top-ranked cities by conflict score, the top 20 percent, had an average density of 137 PpH, which was 78 percent higher than the average density of the remaining 160 cities, which was 77 PpH. When we examined the 78 cities that experienced at least one conflict, the top 40 cities were 40 percent denser than the remaining 38 cities, whose average density was 98 PpH circa 2014 (Table 7; Fig. 8).

After testing the model on the Colombian data, we ran another regression to examine the effect of organized violence on built-up area density in the global sample while controlling for population size and GDP per capita PPP (Table 8). We found that all three variables were statistically significant in the model. For the global sample of 200 cities, we found that for every 10 percent increase in conflict count, there was a 0.6 percent increase in density on average. This effect is smaller than population and GDP per capita, but is still statistically significant as it adds explanatory power to the model. If a hypothetical city in the bottom 160 cities of the global sample, as ranked by conflict score, became one of the top 40 cities in the sample, we would expect its density to increase by 36 percent. Comparatively, for every 10 percent increase in population we expect a 1.7 percent increase in density on average; and for every 10 percent increase in GDP per capita PPP, we anticipate a 4.7 percent decrease in density on average (Table 8). GDP per capita and population size are stronger predictors in the model, but the addition of conflict count improved the adjusted R-squared of the model from 0.461 to 0.474.

When we stratified the sample to look exclusively at the 78 cities with at least one conflict, we found that if one of the bottom 38 cities moved into the top 40 cities, we would expect the average density of that city to increase by 32 percent after controlling for population size and GDP per capita PPP (Table 9). But fitting the conflict score directly

Table 6
Linear regression models with log built-up area density circa 2014 as the dependent variable in the Colombian sample.

Predictor Variable	Coefficient B	Confidence Interval	P-value
Log Population Size	0.03	[0.05, 0.12]	0.07
Log Conflict Count	0.13	[0.03, 0.18]	0.002

Table 7
Average built-up area population density with confidence interval in the top 40 global sample of cities ranked by conflict scores compared to the rest of the cities with at least one conflict over period 1990 to circa 2014.

Mean [Confidence Interval]	1990	2000	circa 2014
Top 40 Cities	205.3 [158.2–252.4]	151.1 [126.7–175.5]	136.7 [116.8–156.6]
Rest 38 Cities with Conflicts	226.2 [164.4–288.1]	153.4 [119.0–187.7]	98.5 [77.3–119.6]
All Cities with Conflicts (N = 78)	218.4 [179.3–257.4]	152.5 [131.2–173.8]	112.8 [97.9–127.7]

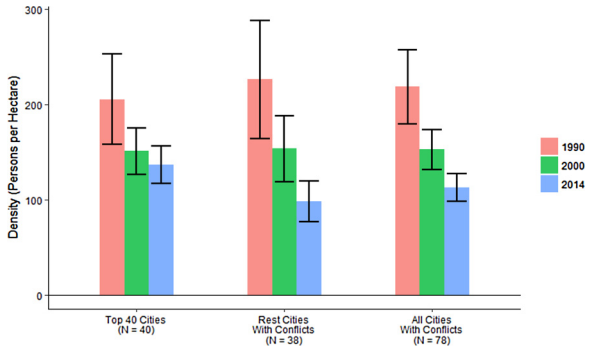

Fig. 8. Average population density with confidence interval in the top 40 global sample of cities ranked by conflict scores compared to the rest of the cities with at least one conflict over period 1990 to circa 2014. (Atlas of Urban Expansion–2016 Edition).

Table 8
Linear regression models with log built-up area density as the dependent variable in the global sample of 200 cities.

Predictor Variable	Coefficient B	Confidence Interval	P-value
Log Population Size	0.17	[0.12, 0.23]	< .0001
Log City GDP per capita	−0.51	[-0.60, −0.41]	< .0001
Log Conflict Count	0.06	[0.01, 0.11]	0.02

Table 9
Multiple linear regression models with log built-up area density as the dependent variable in 78 global cities with at least one conflict.

Predictor Variable	Coefficient B	Confidence Interval	P-value
Log Population Size	0.17	[0.08, 0.25]	< .0001
Log City GDP per capita	−0.44	[-0.57, −0.30]	< .0001
Top 40 Cities	0.28	[0.05, 0.51]	0.018

is not statistically significant due to weakened statistical power caused by reduced sample size.

6. Conclusion

> "Neither floods nor plagues, famines nor cataclysms, not even the eternal wars of century upon century, have been able to subdue the persistent advantage of life over death"

Gabriel Garcia Marquez "The Solitude of Latin America, (Nobel Lecture, 1982)"

Security matters. Security affects where people live and how they live. For most of human history, it has been a key driver of urbanization. The relationship between safety and urbanization has largely been forgotten as economic development has taken a greater role and cities have been referred to as labor markets (Bertaud, 2018). This new age of terrorism, however, has reintroduced safety to the conversation.

Where and how people choose to live is influenced by their perceived sense of safety. In this paper, we have demonstrated that invisible walls inhibit urban expansion when organized violence is present. People seek out pockets of safety and move from relatively less safe areas, which forces built-up area residential densities higher.

Further research must address how relative security at different scales has affected urbanization. The theoretical frame of this paper argues that there is an enduring reflex to survive and that the product of this decision is made visible through the process of urbanization. We also see it at a more granular level in cities around the world that have become dominated by gated communities that communicate a desire for safety and fear of the surrounding city (Landman, 2004). In many cities, invisible divides are present, whether in Chicago or Medellin, as gangs and violence stigmatize entire neighborhoods (Wacquant, 2007). In this paper, we focused on the meso-level, the built-up urban area, but there's more research to be done on neighborhood effects. This research will also help make sense of how built-up area residential density varies across nations over time. In Colombia, for instance, PDET cities saw built-up area residential densities decline between 1990 and 2000 before increasing between 2000 and 2015. This research will require more fine-grained data that reports violence precisely. Lastly, more georeferenced data at a finer scale, meaning more precise locations of where violent events occur, is needed to assess more accurately relative security's role in the process of urbanization.

As countries like Colombia seek to end civil conflicts and transition to peace, we anticipate new challenges will develop. Colombia's hyperdensity is likely to diminish, a trend that is already present in the data, as concerns over security dissipate and GDP per capita PPP increases. Colombia's National Planning Department (2016) estimates that Colombian cities will absorb an additional 18 million citizens by 2050. If peace holds, the National Planning Department projects that Colombian cities' densities will converge with those in neighboring cities in Latin America and will decline by 1.2 percent per year. The combination of population growth and falling densities suggest a 215 percent increase in land area needed to accommodate at least 5.5 million new housing units. This estimate does not account for Colombia's annual 3.73 percent economic growth rate from 1990–2015. When we extended this rate of economic growth into the future, we found that densities will decrease by an additional 203 percent. If improvements in security lead to even higher GDP per capita in the country, we would anticipate even greater declines in densities.

Based on current projections, Colombia will approach peak population by 2045. Planning decisions made over the next 20 years will determine land-use patterns into the next century. How and where cities develop and whether it is done in a sustainable and equitable manner will be decided during this period. Negotiating peace in Colombia was an arduous process. Now that it is here, a new spate of decisions must be made regarding the development of a unified nation.

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