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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 density and organized violence. Security for most of human history has been one of the determinant factors for city development and growth; this remains true today. What is new, and the focus of this paper, is that the prevalence of organized violence increases the density of adjacent areas. Throughout history, those fleeing organized violence have sought refuge in cities or neighboring towns 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 conflict between guerilla groups and the Colombian national government, its cities were denser than neighboring cities. 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 significantly denser as well. We conclude that organized violence creates an invisible wall that contains the outward expansion of cities adjacent to organized conflict.

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1. Introduction: Background, Rationale, and Objective

Cities have always been places of refuge and commerce (Childe 1950; Mumford 1968; Wu and Gaubatz 2013). Cities allowed 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). Markets flourished as people's faith in rules and the certainty of contracts grew. The social experiment of the city, the clustering together of strangers, thrived, in part, because of the perception of safety and certainty. Early cities projected this guarantee of safety through the construction of walls that ensured that those within the city would be safe. As cities flourished and development spread beyond the city walls, new walls were added as more land was incorporated into the city. While many walled cities were sacked again and again, and life inside the walls was often perilous, the safety engendered by city walls defined cities and distinguished them from the neighboring countryside. It comes as no surprise, therefore, that in Chinese "the traditional words for city and wall are identical, the character 城 (chéng) standing for both a city and the wall of a city" (Chang 1970, p.64n3).

As nation-states absorbed city-states through the 19th century, the responsibility for maintaining order shifted from the city to the nation. Defense and security, the previously elemental purpose of cities, lost its valence and allowed leaders to invest in sewers and parks rather than ramparts. Louis XIV, the French

king, to take one example, enlarged his empire through military conquests in the 17th century, which enabled him to raze fortifications in Paris and transform the walled city into a city with new spaces for walking and leisure where walls used to loom (DeJean 2014, pp. 97-121).[1]

City walls may have represented a physical break from the surrounding landscape, but the process of urbanization spread beyond the old walls and united larger metropolitan areas. Beauregard (2018) collapses the distinction between city and suburb when he writes that "the central city and its suburbs are interdependent; they are joined together by business relationships, the commuting of workers from one to the other, political bodies that manage water and transportation on a regional basis…" (p.12). This process of urbanization, similar to the formation of early cities, could only occur at this greater scale once the threat of invasion receded.

While safety and security catalyzed urban and metropolitan development around the world, there are important caveats to this narrative of inexorable expansion and peace. 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). Concerns about street crime have also been shown to have a dampening effect on population growth (Cullen and Levitt 1999). Baker and Bulte (2010) argue the opposite: even though cities like Paris, Hamburg, and London became the target of raiding Vikings, the lingering threat of violence

[1] Louis XVI rebuilt walls in the 1780s as a means of traffic control, and they remained until the 1920s.

incentivized greater agglomeration so that these medieval cities could defend themselves from attacks.

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 density of cities. We examined the broad literature on urbanization and violence and the narrower literature in Colombia to understand the multiple dimensions of violence and establish a relationship between "relative security" and urban form. We examined two types of empirical data to evaluate the relationship between relative security and density: first, we drew on comparative spatial data on urban densities from the *Atlas of Urban Expansion--2016 Edition* and the *Colombian Atlas of Urban Expansion* (Angel et al. 2016; Angel et al. N.d.). These two datasets contain a wealth of spatial data, including average densities and boundaries of built-up areas. The *Atlas of Urban Expansion* includes spatial data on 200 global cities that form a representative sample of the universe of 4,231 cities that had 100,000 people or more in 2010. The *Colombian Atlas* uses the same definitions and methods as the *Atlas of Urban Expansion*, but focuses exclusively on a set of 109 Colombian cities out of 1,102 municipalities.

Second, we combined this spatial data with data on conflicts. First, we used a list of 169 Colombian cities named in the 2016 Teatro Colon peace agreement between the Revolutionary Armed Forces of Colombia (FARC), a guerrilla group, and the Colombian government. We selected these cities because they were identified as being the main cities that were affected by the ongoing domestic strife in Colombia and were in need of additional resources to catalyze development.

Second, we integrated data from the Uppsala Conflict Data Program (UCDP). This dataset contained geocoded data on conflicts dating back to 1975 (Uppsala Conflict Data Program n.d.). It is important to note that the UCDP data is time-series data from 1975, while the list of cities included in the Teatro Colon peace agreement is from 2016 and reflects the geography of the conflict at that moment in time.

Once we collected the empirical data, 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 literature on violence and urbanization, with an emphasis on Colombia. 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

As we began our research, we quickly noticed that the terms violence, conflict, and insecurity were 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 et al. (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 et al. (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, muggings and acts of war that involve two sovereign nations do not factor into our analysis. When the concept of conflict and organized violence is pulled apart and examined in this way, its impact

on cities changes based on the scale, combatants, and victims of conflict and organized violence. The main driver of increased density is relative security, migration from high-risk areas to the city or "pockets of safety" within the city. Beall et al. (2013, p.3069) 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).

The fluid nature of cities, specifically the breakdown of strong kinship-based ties that were dominant in rural villages, affords residents a level of anonymity if necessary. 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 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. This, in turn, limits the outward growth of the city and forces the existing built-up area to fill in with new residents, which leads to greater density. People migrate from areas plagued by organized violence to more secure areas. 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 and 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 cities that were 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."

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.

While the countryside has been the preferred landscape to nurture rebellions, more recent conflicts have shifted tactics by targeting cities in the hope of scoring short-term media attention with little chance of long-term military success. Dense cities offer attractive targets to terrorists who want to create attention-grabbing spectacles by injuring the greatest number of people. Glaeser and Shapiro (2012) term this the "target effect." When cities become targets of organized violence, their populations decline as their citizens flee to safer cities or into the rural countryside. During the Russian civil war in the late 1920s, cities like Moscow and Saint Petersburg saw dramatic population losses. Between 1910 and 1920, the population of Moscow declined by 33 percent, from 1,533,000 to 1,028,000. Population loss in Saint Petersburg was even more pronounced. It fell by 63 percent, from 1,962,000 to 722,000 (Koenker 1985). In the United States, fears of a Soviet atomic strike after 1945 fueled domestic efforts to decentralize its

population, developing the Interstate Highway system as a defensive system that could help distribute the country's population more evenly (Augur 1948 and Dudley 2001).

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 et al 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.

The Colombian Story

Organized violence in Colombia is as old as its history (Pardo 2004). No Colombian has ever known a day of peace. 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 et al. 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. Ibánez 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. (Ibanez and Velez 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 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 density. In fact, the impetus for this study was our realization that the average population density of Bogotá, the capital of Colombia, was anomalous. We found that the average population density within its built-up area was 245 Persons per Hectare (PpH) in 2014. 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 (*Fig. 1*).

Ranking position	Municipality	Built-up Area Density circa 2015
1	Cumaribo, Vichada	528
2	Puerto Guzmán, Putumayo	436
3	Sucre, Sucre	422
4	Francisco Pizarro, Nariño	409
5	Magüí Payán, Nariño	409
6	La Tola, Nariño	399
7	Neira, Nariño	365
8	San Jacinto del Cauca, Bolívar	354
9	Apartadó, Antioquia	341
10	Iles, Nariño	327
11	Mosquera, Nariño	305
12	Barbacoas, Nariño	304
13	La Tebaida, Quindío	303
14	Puerto Santander, Nte. de Santander	270
15	Valle del Guamuez, Putumyao	252
16	El Charco, Nariño	250
17	Gran Bogota, D.C and C/marca	245
18	Orito, Putumayo	231
19	Chinchina, Caldas	230
20	San Juan de Uraba, Antioquia	226
21	Buenaventura, V. del Cauca	216
22	Quimbaya, Quindío	213
23	Sevilla, Valle del Cauca	205
24	Gran Manizales, Caldas	202
25	Circasia, Quindío	195
	Colombian Average > 100,000	170

Ranking position	City Name	Country	Built-up Area Density circa 2015
1	Dhaka	Bangladesh	552
2	Hong Kong	China	467
3	Lahore	Pakistan	391
4	Mumbai	India	369
5	Karachi	Pakistan	365
6	Malegaon	India	322
7	Kinshasa	Congo Dem. Rep.	303
8	Ahmedabad	India	295
9	Manila	Philippines	277
10	Vijayawada	India	260
11	Kolkata	India	251
12	Bogota	Colombia	245
13	Arusha	Tanzania	241
14	Hindupur	India	240
15	Belgaum	India	229
16	Suining, Sichuan	China	227
17	Lagos	Nigeria	209
18	Parbhani	India	205
19	Myeik	Myanmar	201
20	Kanpur	India	194
21	Cebu City	Philippines	192
22	Alexandria	Egypt	191
23	Caracas	Venezuela	190
24	Singapore	Singapore	186
25	Jalna	India	184
	World Average		84

Figure 1: Average built-up area density of 25 densest Colombian cities vs. Average built-up area of 25 densest cities in the global sample circa the year 2014.

As we explored Bogotá's density versus other cities in the global sample, we found that 90 percent of Bogotá's population growth between 1990 and 2015 occurred in areas of the city that were occupied in 1990. 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 area occupied 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.

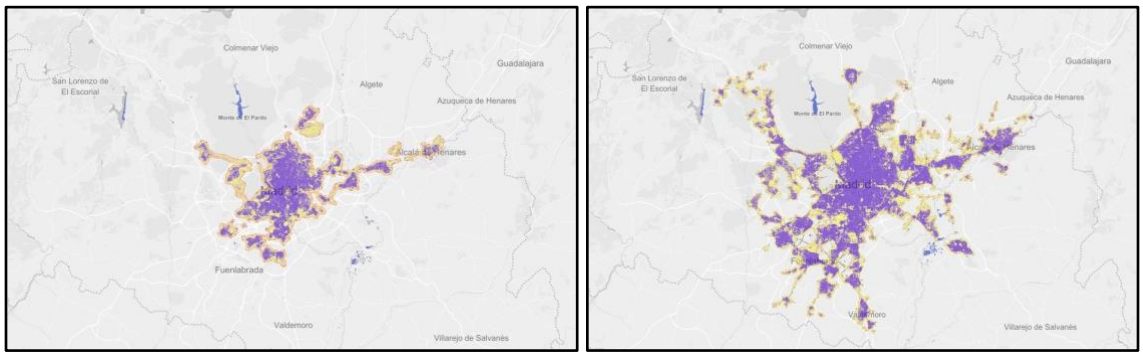

Figure 2: Madrid's built-up area 1991 (left) and its built-up area in 2010 (right).

Bogotá's growth was much more compact than any of the other cities in the smaller sample of 10 cities that we examined.[2] As one sees in Figure 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.

[2] 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..

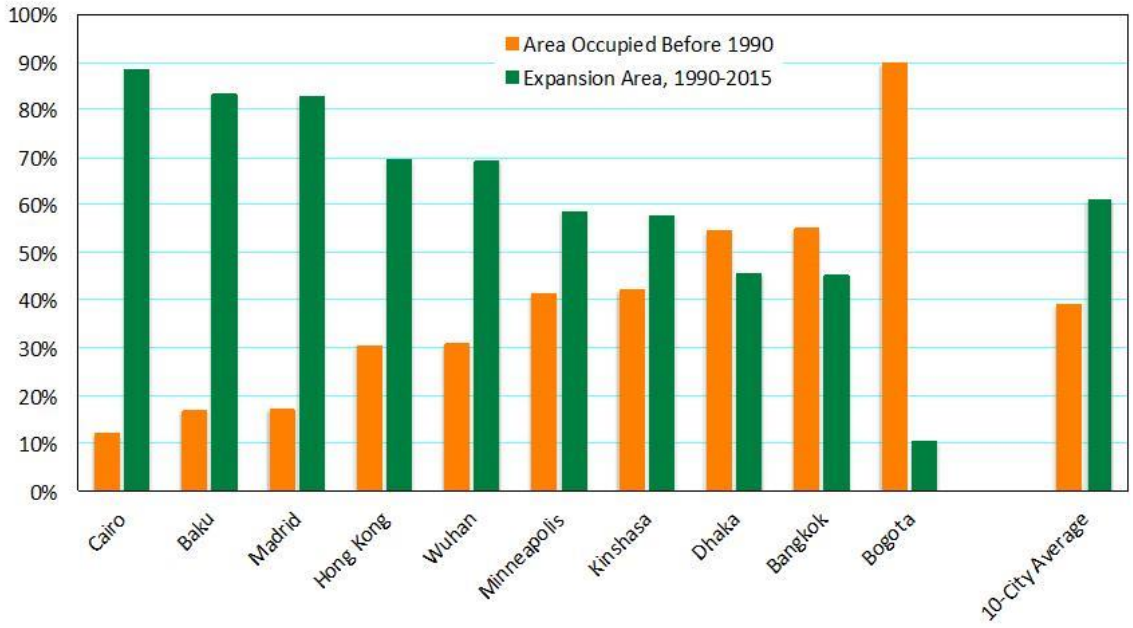

Figure 3: The share of added population between 1990-2015 that was accommodated in areas developed before 1990 against the expansion areas developed between 1990-2015.

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. Bogotá was thirteen times denser than New York City, Apartado was three times than denser Mexico City, and Buenaventura was three times denser than Tokyo. This led us to theorize that the presence of persistent civil conflict in Colombia may help explain why Colombian cities are so much denser than cities around the world.

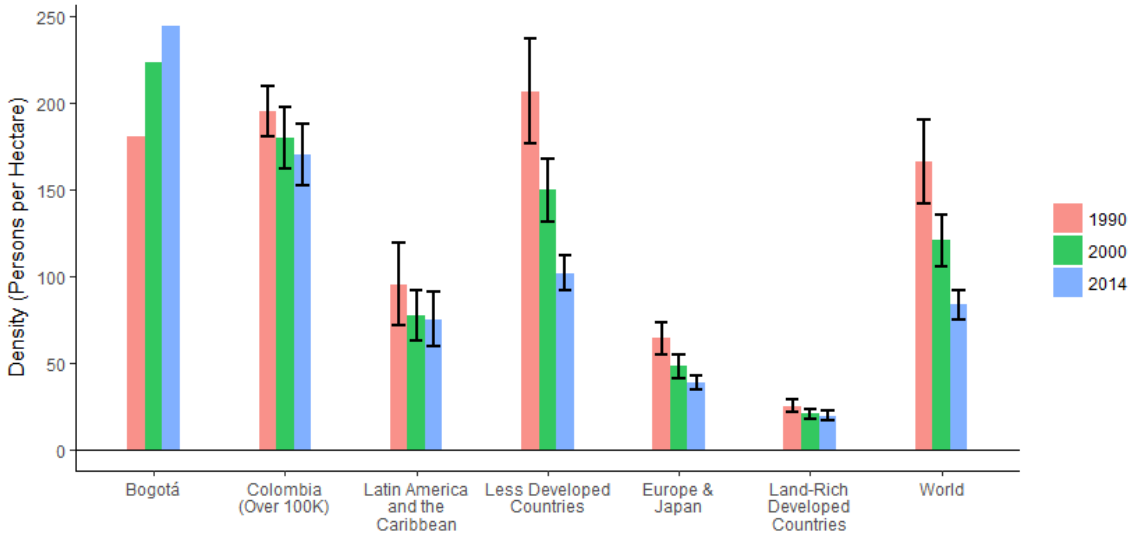

Figure 4: Average population density of built-up area with confidence intervals for Bogotá and Colombian cities with population size over 100,000, compared to other world regions and the world at large in 1990, 2000, and circa 2014.

City and Region	N	1990	2000	circa 2014
Bogota	1	180.6	223.2	244.6
Colombia	20	195.4 [180.6 - 210.2]	180.0 [162.2 - 197.8]	170.1 [152.3 - 187.9]
Latin America and the Caribbean	26	95.4 [71.4 - 119.5]	77.5 [62.8 - 92.2]	75.3 [59.6 - 91.0]
Less Developed	148	206.9 [176.8 - 237.1]	149.8 [131.8 - 167.8]	101.8 [91.5 - 112.0]
Europe & Japan	34	64.1 [54.5 - 73.7]	48.2 [41.2 - 55.1]	38.6 [34.5 - 42.7]
Land-Rich Developed Countries	18	25.2 [21.5 - 29.0]	20.6 [17.9 - 23.3]	19.4 [16.7 - 22.1]
World	200	166.1 [141.9 - 190.3]	120.8 [105.8 - 135.7]	83.6 [74.9 - 92.3]

Table 1: Average built-up area density with confidence interval of Bogotá and Colombian cities compared to regional averages for the the world circa 2014.

3. 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 data on organized violence and georeferenced data on cities in Colombia. We used regression analysis to test the relationship between relative security and 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 (*Figure 5*). 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, 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.[3] The second set of comparative spatial data we relied on was the *Colombian Atlas of Urban Expansion* (*Figure 6*). This dataset was constructed in the same fashion as the *Atlas of Urban Expansion*, but instead cataloged spatial data for 109 Colombian cities.

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

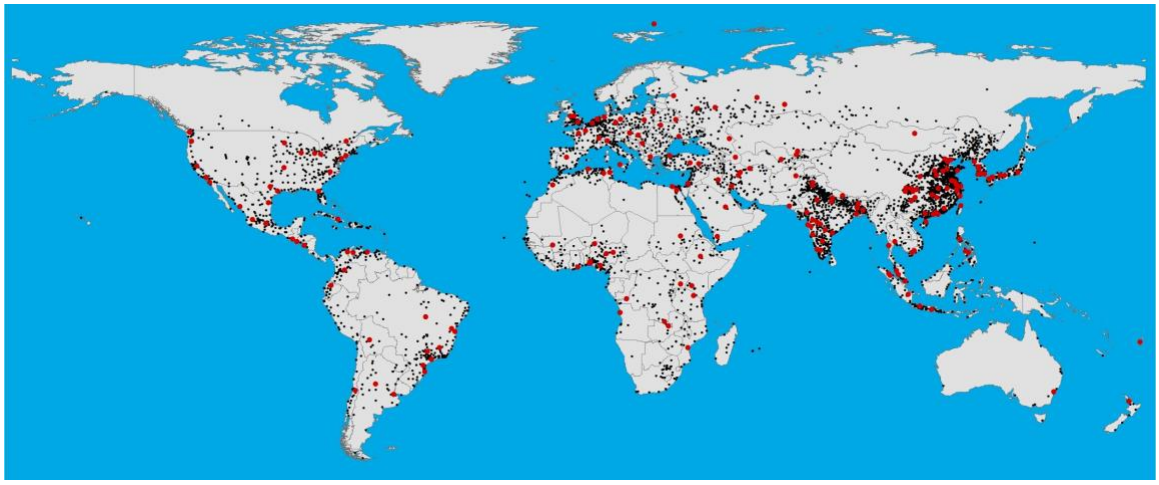

Figure 5: The universe of 4,231 cities in the world that had 100,000 people or more in 2010 and the global sample of 200 cities.

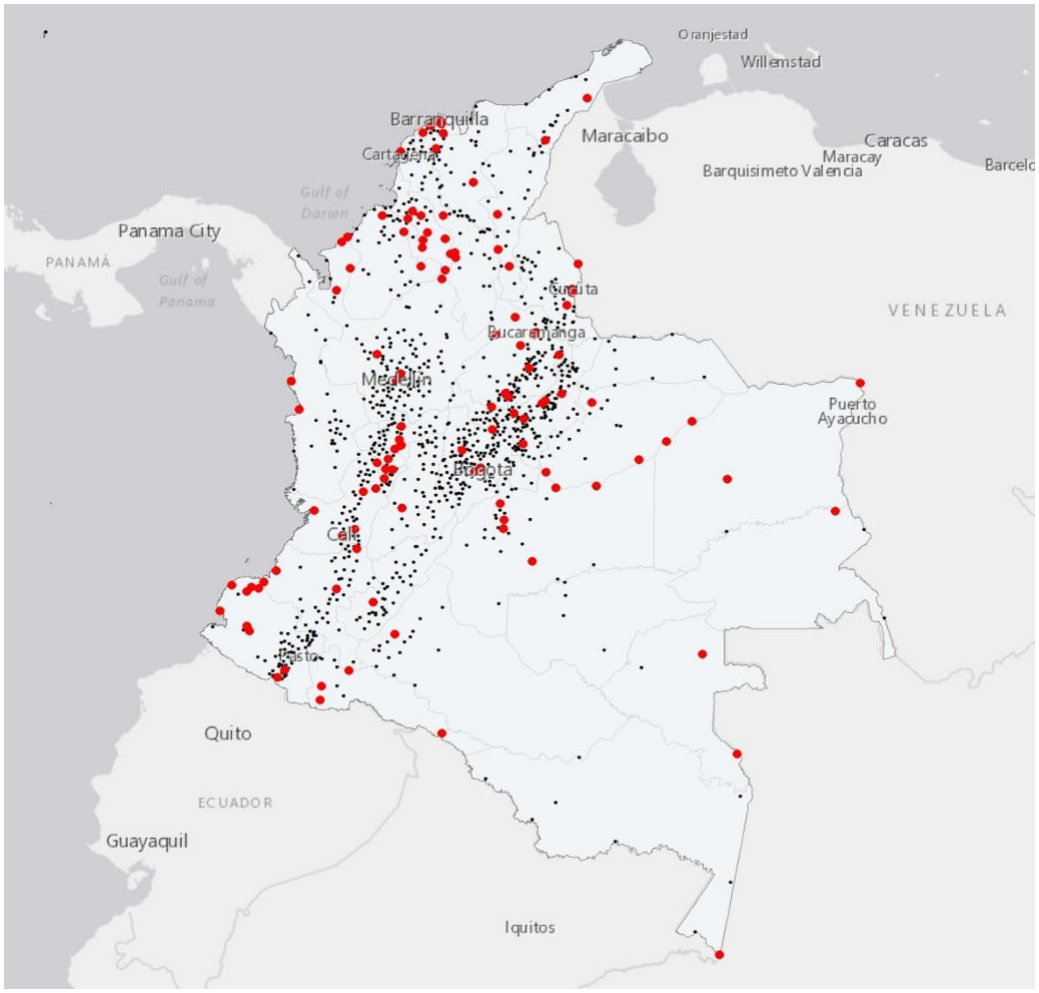

Figure 6: The universe of 1,102 municipalities in Colombia in 2016 and the representative sample of 109 Colombian cities.

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. 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. We captured the concept of relative security by drawing a 50 km perimeter (a two-day walk) around the built-up area of cities that have experienced organized violence.

With all of our data collected, we performed two distinct sets of analysis to investigate our question: Does organized violence influence 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 geography 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 et al. (2011; 2018) the two main drivers of density are population and Gross Domestic Product per capita Purchasing Power Parity (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.

4. Results

We used linear regression analysis to explore the primary drivers of residential density in cities around the world. Our first regression, examined the relationship between density, population, and GDP per capita PPP. When these variables failed to reflect the observed densities we found in Colombia, we executed another regression that accounted for relative security. Using our conflict score metric, we showed that frequent acts of organized violence drive density higher in cities around the world.

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

When we applied the findings from the regression to Colombia we found that they were not robust enough to account for Colombia's hyper-density. Colombia's

GDP per capita PPP in 2015 was $13,825, 11.8 percent below the global average of $15,675 (World Bank n.d.). This lower GDP per capita PPP indicates that Colombian cities should be denser on average, which in fact they were. The model, 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 modeled 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* only 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.

PDETs cities: Cities in Colombia identified as high-conflict cities are denser

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). 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. 7*). In 2014, The PDET municipalities had 224 PpH while non-PDET municipalities had 160 PpH. In other words, PDET municipalities associated with intense conflict were 40 percent denser than the rest of the sample. We confirmed the statistical significance of this result by running a two-sample t-test.

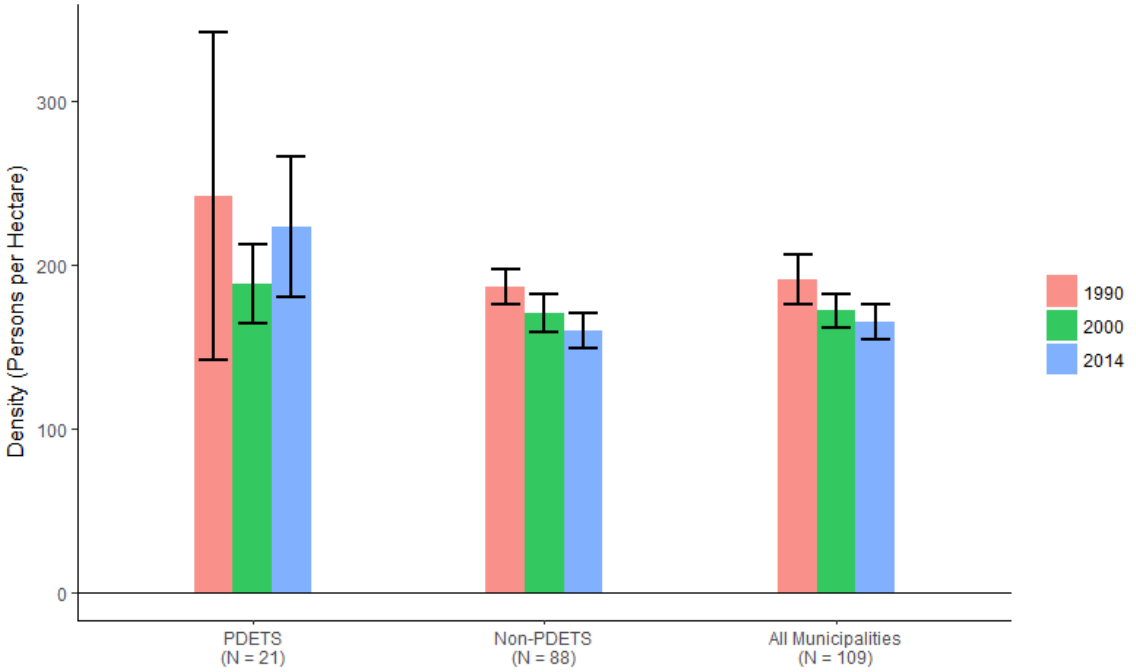

Figure 7. Average built-up area population density with confidence interval for PDET municipalities compared to non-PDET municipalities in 1990, 2000, and circa 2014.

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 2: Average built-up area density with confidence interval for PDET municipalities compared to non-PDET municipalities in 1990, 2000, and circa 2014.

To better examine the relationship between urban density and other 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).

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

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

Colombia	Conflicts	Global Samples	Conflicts	Universe of Cities	Conflicts
Cali, Valle Del Cauca	143	Baghdad, Iraq	2,137	Srinagar, India	2,167
Corinto, Cauca	138	Kabul, Afghanistan	1,224	Mogadishu, Somalia	1,698
Palmira, Valle Del Cauca	124	Tel Aviv, Israel	773	Gaza, Palestine	1,547
Medellin, Antioquia	116	Algiers, Algeria	487	Rafah, Palestine	1,540
Popayan, Cauca	108	Pokhara, Nepal	267	Khan Yunis, Palestine	1,535
Bogota, Santafe De Bogota D.C	94	Sialkot, Pakistan	235	Anantnag, India	1,520
Salamina, Caldas	89	Karachi, Pakistan	210	Jalalabad, Afghanistan	1,440
Puerto Gaitan, Meta	88	Kigali, Rwanda	170	Baghdad, Iraq	1,429
Corozal, Sucre	87	Tijuana, Mexico	165	Mosul, Iraq	1,368
Florencia, Caqueta	86	Sana, Yemen	147	Beersheba, Israel	1,362

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 Colombia sample of 109 cities, the global sample of 200 cities, and the universe of 4,231 cities.

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. 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. We chose the top 20 percent of the 109 Colombia cities to compare with the rest of the sample. These 22 cities endured 1,803 incidents of organized violence from 2000-2015, 82 incidents of conflict per municipality or 5.45 events per year. In the meantime, the rest of the Colombian sample had 1,720 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 density of 181 PpH compared to 146 PpH in the rest of the sample *(Fig. 8)*.

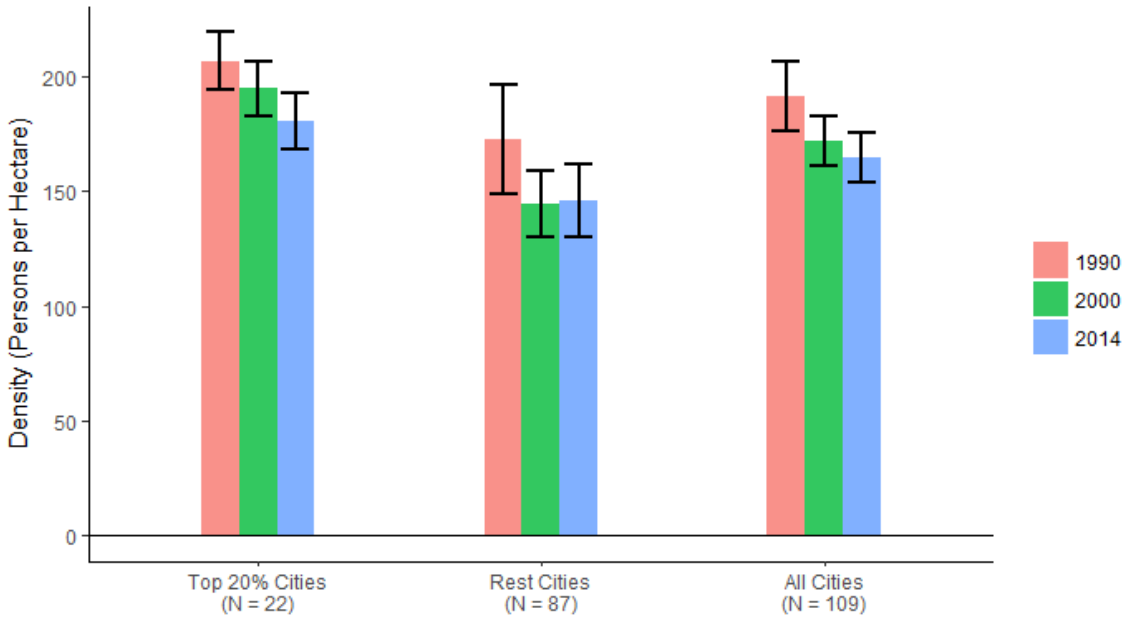

Figure 8. Average population density with confidence interval of the top 20 percent Colombian cities ranked by conflict score compared to the rest of the cities over period 1990 to circa 2014.

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]

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.

When we controlled for population within Colombian cities, we discovered that the conflict score statistic was a significant predictor for 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.

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

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 organized violence is not spread evenly around the world. When we mapped 15 years of these events, we found that the majority of the world was free from organized violence. 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 our list with 2,137 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 correlated 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 (*Fig*. 9).

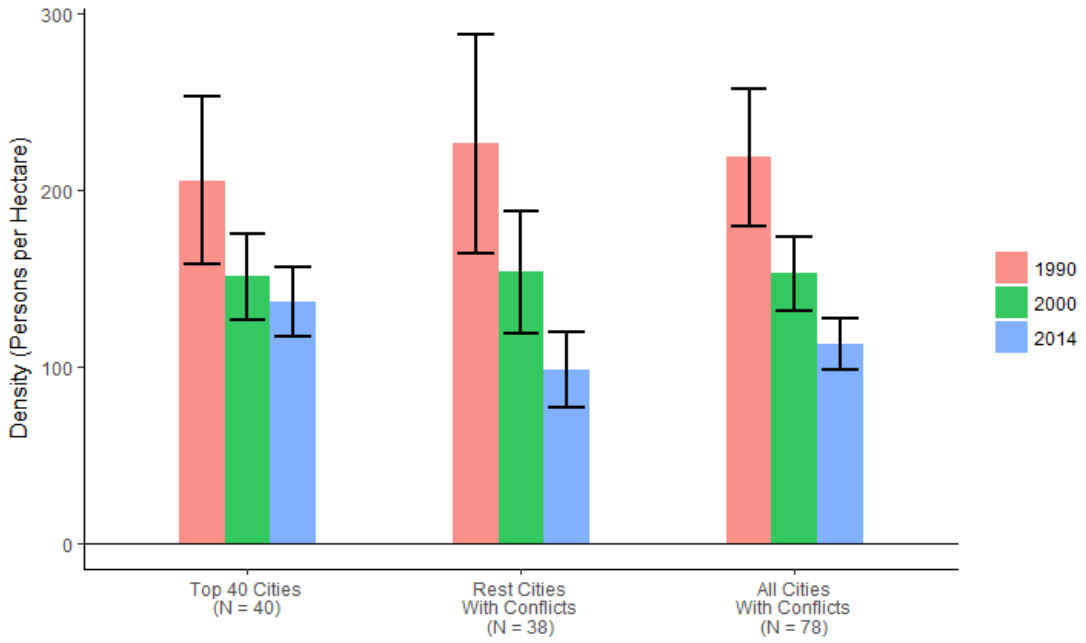

Figure 9: Average population density with confidence interval in the top 40 global sample of cities ranked by conflict scores compared to the rest of the cities with at least one conflict over period 1990 to circa 2014.

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]

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.

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. 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. 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.

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

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. But fitting the conflict score directly is not statistically significant due to weakened statistical power caused by reduced sample size.

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

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.

5. 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 city building. The relationship between safety and urbanization was largely forgotten when nation-states supplanted city-

states. This new age of terrorism, however, has reintroduced safety to the conversation.

Where and how people settle is greatly influenced by their perceived and real safety. In this paper, we argue that invisible walls slow down urban expansion when organized violence is present. People seek out pockets of safety within urban centers, move from relatively less safe areas and force densities higher. This enduring reflex to survive is made visible 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).

Further research must address how relative security at different scales has affected urbanization. Can America's suburban exodus after World War Two or the West's recent urban renaissance be attributed to changes in relative security? How does day-to-day violence influence people's decisions to live in cities (Zeiderman 2016). How has the concept of "transportation risk" contributed to suburbanization or the densification of pockets of safety?

As countries like Colombia seek to end civil conflicts and transition to peace, we anticipate new challenges will develop. Colombia's hyper-density is likely to diminish as concerns over security wane and GDP 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 pressures in Colombian cities 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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