

Jiang, Yi; Laranjo, Jade R.

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METROPOLITAN AREA DELINEATION AND RESILIENCE UNDER A PUBLIC HEALTH CRISIS

EVIDENCE FROM THE PHILIPPINES

Yi Jiang and Jade R. Laranjo

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Yi Jiang and Jade R. Laranjo

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Yi Jiang (yijiang@adb.org) is a principal economist and Jade R. Laranjo (jlaranjo@adb.org) is an economics analyst at the Economic Research and Development Impact Department, Asian Development Bank.

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6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines
Tel +63 2 8632 4444; Fax +63 2 8636 2444
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ABSTRACT

We delineate metropolitan areas (MAs) in the Philippines using cellphone user flow data to proxy for daily commutes. The exercise identifies a number of large MAs that are not officially recognized, and different spatial extents for the three officially designated MAs. The urban system aligns more closely with Zipf's Law when the delineated MAs are considered. MAs with a population exceeding 1 million have grown faster than officially defined urban areas as well as the country as a whole. The mobility restrictions adopted during the coronavirus disease (COVID-19) pandemic had profound impacts on the MAs. MAs experienced fragmentation and contraction when mobility was severely restricted in the first few weeks of the outbreak. As restrictions eased, many MAs swiftly rebounded in size with previously separated municipalities reintegrating into the agglomeration. Regression analysis highlights that proximity, administrative boundaries, accessibility, and labor market complementarity between the core and peripheral municipalities are important factors driving MA formation.

Keywords: metropolitan areas, COVID-19, urban resilience, labor market

JEL codes: I18, O18, R12, R58

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1. Introduction

Metropolitan areas transcending administrative boundaries within a country arise as urbanization progresses. They serve as vital engines for economic growth by operating as functionally autonomous spatial entities and generating significant agglomeration benefits. Yet, it is uncommon to observe systematic practice of officially designating, planning, and managing metropolitan areas in developing countries. The Philippines, for instance, has formally recognized only three metropolitan areas—Metro Manila, Metro Cebu, and Metro Davao—since the 1970s. They consist of merely 45 cities and municipalities out of over 1,600 nationwide. Furthermore, their geographical scopes have remained the same since their inception.¹

Given that economic connectivity and urban expansion are rarely confined within administrative boundaries, it becomes imperative to delineate appropriate urban agglomerations—metropolitan areas in this context—for both research and practical purposes. Firstly, delving into urbanization necessitates a profound comprehension of the urban system, city dynamics, and the benefits of agglomeration specific to the country. Relying solely on administrative city definitions may yield disparate and often misleading findings. Secondly, seamless coordination across jurisdictions is critical for the efficient functioning of urban agglomerations. Effective urban planning and management requires recognizing the spatial extent of these agglomerations, followed by the establishment of coordination institutions and mechanisms.

¹ City and municipality are the subnational administrative units at the same level (below province) in the Philippines. We use city and municipality interchangeably in the paper.

In this study, we employ the commute-based algorithm introduced by Duranton (2015) to delineate metropolitan areas within the Philippines. Leveraging hourly cellphone user flow data at the municipality level from January to September 2020, we construct average daily flows to approximate commuting patterns between municipalities by week. Our analysis reveals a high correlation between the cellphone-based proxies and commuting flows estimated from Census microdata. Notably, utilizing cellphone data enables us to examine the dynamics of metropolitan areas within a much shorter timeframe, on a weekly basis, as opposed to the decade-long internals typically required by census data.

Our data, which spans periods before and after the coronavirus disease (COVID-19) outbreak, allows us to explore several interrelated questions. First, what does the urban landscape of the Philippines look like before the pandemic when we consider functional urban agglomerations beyond administrative boundaries? What roles do the metropolitan areas play in the urbanization process? How does the delineation by pre-pandemic commuting flows compare to the administrative definitions of the three officially designated metropolitan areas?

Second, with the delineation results during the pandemic, when quarantine policy stringency varied over time, we can investigate how the strict quarantine policies implemented by the Government of the Philippines immediately following the COVID-19 outbreak affected the metropolitan areas, and whether the changes persisted or if metropolitan areas recovered as quarantine policies were relaxed?

Finally, our ability to consistently observe metropolitan areas in a dynamic setting allows us to examine the factors—such as geography, administrative boundaries, infrastructure, and policies—that drive their formation or bolster their resilience. In

particular, we develop measures of labor market complementarity between the core and peripheral cities within a metropolitan area to assess the extent to which these areas function as integrated labor markets.

The paper contributes to the growing literature on delineating metropolitan areas (Duranton 2021). While our approach is similar to those used by Bosker, Park, and Roberts (2021) for Indonesia, Chen, Gu, and Zou (2022) for the People's Republic of China (PRC), and Adachi et al. (2020) for Japan, there are some unique features in our study. Specifically, we examine the dynamics of metropolitan areas during one of the largest public health crises in history. Governments across the world adopted strict mobility restriction policies to curb the spread of the disease, which threatened the stability of cities. Our findings reveal that in a lower-middle income country, metropolitan areas experienced fragmentation and contraction under these stringent quarantine measures. However, they also exhibited strong resilience, rapidly recovering once the policies were relaxed.

With this evidence, the paper also speaks to the literature on urban resilience. For instance, Davis and Weinstein (2002) demonstrate that cities are robust to large temporary shocks from war. More recently, Kocornik-Mina et al. (2020) show that cities are resilient to shocks from disasters. We extend this literature by showing that shocks created by public health policies only have temporary effects on urban agglomerations.

Furthermore, using policy adoption and adjustments during the pandemic as a natural experiment, we explore the forces driving urban agglomeration. Beyond proximity and accessibility, we demonstrate that labor market complementarity plays a crucial role in spatially integrating local administrative units into metropolitan areas. This finding

provides fresh suggestive evidence that improved labor market matching is one of the primary benefits provided by large urban agglomerations (Duranton and Puga 2004).

The rest of the paper is organized as follows. Section 2 provides an institutional background on the administrative divisions and the three officially designated metropolitan areas of the Philippines. Section 3 introduces the data and methodology used in the study. Section 4 focuses on the delineation of metropolitan areas before the pandemic, while section 5 examines the dynamics of metropolitan areas during the pandemic. Section 6 presents a regression analysis of the factors driving metropolitan area formation. Section 7 concludes the paper.

2. Administrative Divisions and Metropolitan Areas in the Philippines

The Philippines is an archipelago with 7,641 islands covering a total land area of 300,000 square kilometers (km²). It is divided into three major island groups: Luzon, Visayas, and Mindanao. According to the 1991 Local Government Code (LGC), the local governance of the country is structured in a hierarchy of political and administrative system with province as the highest local government unit (LGU), followed by city and municipality, and then barangay as the lowest unit. Currently, there are 82 provinces, 149 cities, 1,485 municipalities, and 42,001 barangays (Philippine Statistics Authority [PSA] 2023a).

While cities and municipalities are both LGUs under provinces,² they differ primarily on population size and annual income. Municipalities are relatively small, with a minimum population of 25,000 on a contiguous territory of at least 50 km² and a minimum annual average income of ₱2.5 million, in 1991 constant prices, for the last 2 consecutive years. Cities are categorized into three main categories: highly urbanized, component,

² Thereafter, we often refer to cities and municipalities as LGUs.

and independent component cities. Highly urbanized cities are those with a population of at least 200,000 residents and an annual income of at least ₱50 million, based on the 1991 constant prices. Provinces do not have jurisdiction over highly urbanized cities. Component cities, on the other hand, fall short of meeting these criteria and are thus considered part of the provinces wherein they are geographically situated. Independent component cities enjoy autonomy from their respective cities while residents of these cities are generally restricted from voting for elective provincial officials, unless expressly permitted. Across the nation, there are 33 highly urbanized cities, 111 component cities, and 5 independent component cities.

There are three officially recognized metropolitan areas in the country (National Economic Development Authority [NEDA] 2017)—Metro Manila, Metro Cebu, and Metro Davao. Situated in each of the three major island groups, these metropolitan areas serve as vital economic hubs within their respective regions. Metro Manila has 17 neighboring cities and municipalities, Metro Cebu has 13, and Metro Davao has 15. According to the 2020 Census of Population and Housing (CPH), the country's total population exceeds 109 million, with approximately 54% residing in urban residents and 18.3% from these three metropolitan areas (PSA 2021).

Established in 1975, Metro Manila, the largest and most densely populated metropolitan area in the Philippines, comprises 16 highly urbanized cities and 1 municipality, with a population of 13.5 million and a density of 21,765 persons per square kilometer. It serves as the country's center for culture, economy, education, and government, contributing 31.4% to the national gross domestic product (GDP) in 2022 (PSA 2023b). The Metropolitan Manila Development Authority (MMDA) oversees metro-

wide services, with governance vested in the Metro Manila Council (MMC), comprising mayors and league presidents of vice-mayors and councilors.

Meanwhile, Metro Cebu was officially established in 1997. It comprises three highly urbanized cities, four component cities, and six municipalities, with a population of approximately 3.2 million. Its central location makes it a natural hub for economic, commercial, and logistics activities in the Visayas, with extensive domestic and international links (NEDA 2017). The Metropolitan Cebu Development and Coordinating Board (MCDCCB) was created to oversee development plans and programs of the metro, resembling Metro Manila's MMDA but lacking comparable regulatory powers, functioning mainly for coordination and oversight purposes.

Unlike its counterparts, Metro Davao has no legal framework and official definition during its conception in 1993. Only in 2022 did Metro Davao gain its official recognition with the creation of Metropolitan Davao Development Authority (MDDA) whose authorities are similar to MMDA of Metro Manila. Metro Davao encompasses one highly urbanized city, five component cities, and nine municipalities and currently the largest metro in the country in terms of land area at 6,492.8 km² and is next to Metro Manila in terms of population size at 3.3 million.

3. Data and Methodology

3.1 Data

We accessed hourly cellphone user flow data between municipalities in the Philippines from January to September 2020, provided by a major local telecom service provider. We summed the flows between 4 a.m. and 10 a.m. to proxy for daily commuting flows, then averaged these sums across working days each week to obtain weekly commuting flows.

The processed data covers a period of 40 weeks. Upon inspection, however, the flow data for weeks 18 to 26 (May and June) exhibited irregular hourly profiles with unclear underlying causes. Therefore, we excluded these 9 weeks from our analysis focusing on the remaining 31 weeks.

The Government of the Philippines began imposing nationwide “community quarantine” policy centered around mobility restrictions on 16 March 2020 (week 12 in our data). The stringency of this policy was adjusted periodically at the local level throughout the pandemic years.³ Our effective data can be divided into three sub-periods, pre-pandemic from week 1 to 11, strict mobility restriction from week 12 to 17, when most areas of the country were under the highest quarantine policy, and relaxed restriction from week 27 to 40, featuring reduced quarantine measures in most of the country.

To validate that the cellphone-based flows are a good measure of work-related mobility, we correlated them with commuting flows between municipalities derived from the 2010 Census of Population and Housing microdata.⁴ The correlation coefficient between census-based commuting flows and cellphone-based morning flows is around 0.95 for all pre-COVID-19 weeks (weeks 1 to 11), suggesting that the latter is a reliable measure of work-related mobility across the Philippines.

Additionally, we compiled week-municipality-specific quarantine policy data, municipality-level population from the 2020 Census, road densities from OpenStreetMap, and employment by sector from the 2018 List of Establishments. These datasets were

³ The policy was classified into four levels: enhanced community quarantine, modified enhanced community quarantine, general community quarantine, and modified general community quarantine, with decreasing degree of stringency. Jiang, Laranjo, and Thomas (2022) has more detailed documentation of the distribution of restriction policies over time and space.

⁴ Form 3 data of the latest 2020 Census, which is related to employment including place of work, has not been published.

used in delineation exercises or regression analysis to understand the driving factors of metropolitan dynamics.

3.2 Commute-based Delineation Approach

We apply the algorithm developed by Duranton (2015) to the weekly commuting flows constructed above. The algorithm involves iterative aggregation steps with a pre-determined threshold for the share of commuters from an origin that a destination accounts for. The process begins with a raw matrix, where rows represent the origin municipalities and columns represent the destination municipalities. Each cell contains the share of commute flows from the origin to the destination, summing to 1 for each row.

The algorithm requires that an origin municipality be eligible for aggregation to a destination if the share exceeds the selected threshold. If an origin has multiple destinations exceeding the threshold, it will be aggregated to the destination with the largest share. When the shares between two municipalities exceed the threshold in both directions, the smaller municipality is aggregated to the larger one. In cases of chain aggregation, such as municipality A to B and B to C, the final link (B to C) is implemented.

After each iteration, the matrix will be updated by consolidating municipalities that meet the criteria, and the commute shares are recomputed for the new origins and destinations. A new round of aggregation then starts. This process continues until no new aggregations are feasible.

The threshold plays a key role in the delineation exercise, but there is no theoretical guidance on the optimal value. We experimented with different thresholds, narrowing it down to 3% to 6%. A threshold above 6% yields very few and small metropolitan areas, while a threshold below 3% leads to extraordinarily large agglomerations that exceed

feasible daily commuting limits. Furthermore, a threshold of 5% or 6% divides the highly integrated Metro Manila into multiple units during the pre-pandemic weeks. Conversely, a 3% threshold results in overly extensive coverage for Metro Manila, making daily commuting from peripheral cities to the core area unlikely. Therefore, we consider 4% the most preferable threshold, with results from 3%, 5%, and 6% thresholds reported for comparison when useful.⁵

4. Pre-pandemic Results

We conduct delineation using weekly flow data and four thresholds from 3% to 6%. Figure 1 shows the number of delineated units—aggregated municipalities plus remaining individual municipalities—by week and threshold. The patterns across different thresholds and over time are striking. Conforming to the intuition, the number of delineated units decreases with the value of the threshold regardless of the week we look at. In other words, more municipalities are aggregated with lower threshold. The chart exhibits three plateaus corresponding to pre-pandemic, strict mobility restriction and relaxed restriction periods closely. The rest of the section will focus on metropolitan areas (MAs) delineated before the pandemic (week 2 data), while leaving the dynamics over time to the next section.

⁵ Higher threshold levels are adopted in the literature such as 10% in both cases of Colombia (Duranton 2015) and the PRC (Chen, Gu, and Zou 2022). This could be attributed to the larger units of analysis in our study, which involves 1,634 cities and municipalities covering a population of 112.2 million in 2020. In comparison, Colombia had 1,100 municipalities for a population of 44.8 million in 2010, and the PRC had 37,647 townships for a population of 1.38 billion in 2015. According to Duranton (2021), the effectiveness of a threshold can depend significantly on the spatial scale of the units of analysis.

4.1 Large Metropolitan Areas

Table 1 reports the 19 large MAs with at least 1 million residents in 2020 delineated under the preferred 4% threshold. Figures 2a–2c (left panel) visualize them (as well as those with population ranging from 0.5 million to 1 million) by island groups.

These large MAs, identified by their core city names, encompass 381 cities and municipalities hosting a population of more than 55 million, half of the national population.⁶ Out of these 19 MAs, 9 are in Luzon, 3 in Visayas, and 7 in Mindanao. The distribution is sensible as the Luzon islands group accounts for 59% of the entire population of the Philippines and is dominated by the large single island of Luzon. Visayas' population is slightly smaller than that of Mindanao, but it consists of mostly small islands and thus, has fewer large MAs.

These large MAs generally comprise dozens of cities and municipalities except three MAs in Mindanao, and host population multiple times of that of the core city except the one with Zamboanga City as its core city. The core cities are the largest cities within the respective MAs with the exception of the MA containing San Fernando City, wherein Angeles City in the same MA has a bigger population. There are 13 out of 19 large MAs crossing provincial boundaries. This contrasts the case in the PRC, in which 18 out of 189 MAs above 1 million population cross prefecture boundaries (Chen, Gu, and Zou 2022).⁷

⁶ There are another 30 MAs with a population between 0.5 million and 1 million delineated under 4%. They encompass 394 cities and municipalities and total population of 21 million. When the 3% threshold is applied, there are 24 MAs with a population greater than 1 million identified. Nearly 67 million people from 590 cities and municipalities live in these metropolitan areas.

⁷ The Philippines has 82 provinces while the PRC has 256 prefectures. Considering the 1:12 population ratio between the two countries, the population in provinces in the Philippines are, on average, smaller than those in prefectures in the PRC.

Interestingly, four big MAs, whose core cities are Cebu, Iloilo, Davao, and General Santos, integrate municipalities separated by water from the core cities. For MAs centering around Cebu, Iloilo, and Davao, the separating straits are narrow and the island municipalities are all populated with more than 100,000 residents. Building bridges to connect them physically with core areas of the MAs seems to make sense. There are also small islands far from Cebu and General Santos, but sending a significant share of residents by water to the large MAs daily.

Six MAs on the top of the list exceed 2 million in population. The largest MA hosts 23.4 million population, more than six times of the second-largest.⁸ The third- and fourth-largest MAs are neighbors to the MA of Metro Manila in the north and south, respectively. This confirms that the central Luzon area, hosting three of the top four MAs of the country, is the most vibrant region in the Philippines.⁹ The government's flagship infrastructure project, North–South Commuter Railway which is under construction in 2024 and would connect Angeles City, Metro Manila, and Calamba City, is expected to enhance the integration across the three MAs. The MA of Iloilo City ranks fifth on our list. It integrates 38 cities and municipalities, more than other large MAs except the MA of Metro Manila. As previously mentioned, five constituent municipalities with a total population of 187,842 are located on Guimaras island, which is southeast of Iloilo City but separated by sea. The MA of Davao is barely larger than 2 million and involves only four cities and

⁸ The core city is Quezon City instead of Manila City. Quezon City is the most populous city within Metro Manila and surrounding areas. According to the Quezon City website, the city was officially proclaimed the national capital in 1949. However, a presidential decree in 1976 reverted national capital status to Manila while the whole of Metro Manila was designated as the seat of government. We also refer to the MA centering around Quezon City as MA of Metro Manila thereafter.

⁹ In Figure 2a, we can see most MAs above 1 million in Luzon Island are located in central Luzon.

municipalities. It is smaller than the officially defined Metro Davao. We leave a detailed discussion of the three official MAs to section 4.4.

4.2 Zipf's Law with Metropolitan Areas

Zipf's Law states that the size distribution of city populations, with a country, follows a Pareto distribution with shape parameter equal to one. In other words, the population of the n th largest city in a country is $1/N$ times the population of the largest city. There is a vast literature that examines to what extent Zipf's Law holds across different countries and various definitions of cities (Duranton and Puga 2014). For the Philippines, Soo (2005), using a sample of 87 administratively defined cities in 2000, obtains an estimate of the shape parameter equal to 1.08, which is not statistically different from 1.

We estimate the equation:

$$\log\left(R_i - \frac{1}{2}\right) = \beta_0 - \delta \log P_i + \varepsilon_i$$

where R_i is the population rank and P_i the population size of city i . The dependent variable is the log of the rank minus one half to correct a potential small sample bias (Gabaix and Ibragimov 2011). The coefficient δ , the shape parameter of the Pareto distribution, equals 1 if Zipf's Law holds. We use three definitions of cities: three official MAs and administratively defined individual cities and municipalities; delineated MAs under 4% threshold; and delineated MAs under 3%. We exclude cities and municipalities as well as delineated MAs with a population below 50,000 to avoid the inclusion of rural areas and very small cities.

Figure 3 plots the estimated relationships between log rank and log population as well as the underlying data for the three city definitions. Using an administratively defined

sample (n=534), the δ is estimated at 1.543 with a standard error equal to 0.008, which is statistically different from 1. Compared to what Zipf's Law predicts, the result suggests that the small cities are too big and the large cities are too small.

The δ is estimated to be 0.936 and 0.862 for the delineated MA samples under 4% (n=213) and 3% (n=160), respectively. The estimated standard errors (0.016 and 0.021) reject that the estimates are statistically different from 1. As opposed to the administrative sample, the delineated MA samples yield smaller estimates of δ falling on the other side of the benchmark value 1. This is somehow expected because the delineation approach identifies MAs bigger than their official counterparts or large administrative cities and decreases the rank of smaller cities as many of them are merged into big MAs. The lower commuting threshold further rotates the Zipf line counterclockwise as the largest MAs become larger and the number of MAs further decreases.

4.3 Growth of Metropolitan Areas

MAs are generally perceived as vibrant urban agglomerations, where higher wages and better amenities attract people to immigrate. Population growth is thus a good indicator to show to what extent our MA delineation identifies the most economically active areas in the country. The last column in Table 1 reports annual population growth rates between 2010 and 2020 for the 19 largest MAs (holding the delineated scopes constant). Figure 4 plots them against the average growth rates for the country as a whole, across all the cities and across all the municipalities.

First of all, the national population increased by 1.68% per annum over the last census decade. The growth rate for cities, which represent larger urban areas, was 1.81%, higher than that of municipalities (1.59%), which include smaller cities and rural

areas. The difference indicates the continuous urbanization in the country. Notably, the growth across all cities and municipalities encompassed in the largest 19 MAs registered at 1.96% per annum, significantly exceeding the national average and the growth rate of administratively defined large urban areas. This suggests that MAs play a crucial role in driving urbanization.

However, there is significant heterogeneity in growth across the MAs. Among the 19 MAs we identified, the MAs of Calamba City (2.91%), Lipa City (2.84%), Cotabato City (2.73%), and San Fernando City (2.20%) post the highest growth. The proximity of MAs of Calamba City, Lipa City, and San Fernando City to Metro Manila enables them to absorb the spillovers from the capital region. Furthermore, Cotabato City continues to pull many job seekers from rural areas and secondary urban centers in the Mindanao region. In contrast, the MAs of Iloilo City (1.14%), Urdaneta City (1.24%), and Bacolod City (1.27%) show the lowest population growth among the large MAs. For Iloilo City and Bacolod City, the sluggish growth is a reflection of the overall low growth rate in the region of western Visayas, whose steady economic progress was disrupted by destructive typhoons in recent years (NEDA 2023). Meanwhile, the components of the MA of Urdaneta City are mostly rural municipalities with out-migrating populations over the years.

4.4 Three Official Metropolitan Areas

We compare commute-based metropolitan areas of Manila, Cebu, and Davao against their official counterparts. Table 2 shows numbers of constituent cities and municipalities, total land area, population in 2020 and density under official definition, delineated at a threshold of 4% and 3%. Under the 4% threshold, commute-based Metro Manila

encompasses 63 cities and municipalities with a population of more than 23 million living in a land area of 4,895 km². It is a much larger urban agglomeration than the official Metro Manila involving 270% more cities and municipalities, 685% more land and 73% more population. Meanwhile, the average density of commute-based Metro Manila decreases significantly to 4,801 people per square kilometer, one-fifth of the density of official Metro Manila. The scope of Metro Manila expands further when the 3% threshold is applied to delineation. The number of cities and municipalities, land area, and population increases by 37%, 38%, and 17%, respectively, while density decreases by 15% as compared to that for 4%.

If Metro Manila, conservatively defined by the 4% threshold, was in the United States (US), it would surpass the population of the largest Metropolitan Statistical Area (MSA), New York–Newark–Jersey City MSA. However, the land size of this Metro Manila is dwarfed by the majority of MSAs in the US. In the Asian context, the Tokyo MA hosts a population of around 40 million on a land area of 13,500 km², more populous and sprawling than the aggressively defined Metro Manila under the 3% threshold.

Commute-based Metro Cebu is also bigger than its official counterpart, with 92% more cities and municipalities, 132% more land, and 18% more population under the 4% threshold, and 138% more cities and municipalities, 205% more land, and 33% more population under the 3% threshold. While the spatial scope of commute-based Metro Cebu is considerably larger than the official definition, the integrated units are all municipalities with relatively small populations.

In contrast, commute-based Metro Davao is significantly smaller than its official scope. Even under the aggressive 3% cutoff, the number of cities and municipalities in

the delineated Metro Davao is 6 with total population of 2.3 million, as opposed to 15 cities and municipalities with total population of 3.3 million in the official Metro Davao. In fact, we identify another MA centering around Tagum City, which ranks as the seventh largest with a population of 1.7 million (Table 1). It overlaps with a large portion of the official Metro Davao. Geography may partly explain the phenomenon, as some constituent cities and municipalities are located far and not contiguous to the others in the official Metro Davao. Moreover, the official Metro Davao spans five provinces, while the metro governance body has not been set up until very recently, which could also keep the constituent cities and municipalities from integrating in the short term.

In terms of growth, the official Metro Manila increased its population by 1.3% per annum from 2010 to 2020, far below the national average. This is probably due to its already very high density and severe congestion. However, commute-based Metro Manila has grown at a rate of 2%. This suggests that although the official Metro Manila hits its population growth limit (losing people relative to the rest of the country), as the economic center of the country, it continues to attract people at a fast pace to the surrounding areas, with which it forms a larger, rapid-growing MA. Commute-based Metro Cebu has been growing as fast as the official Metro Cebu. The growth rates around 2.1% exceed the national average and the average of the large MAs. This may be a result of absorbing out-migrants from the nearby MAs of Iloilo and Bacolod. Commute-based Metro Davao (2.05%) marginally outgrew the official Metro Davao (1.92%). In view of the slow growth of the MA of Tagum City (1.45%), a certain amount of population may have migrated from one part to the other inside the official Metro Davao.

5. Dynamics of Metropolitan Areas During the Pandemic

To contain the spread of COVID-19, the government started to implement community quarantine policies in mid-March 2020. Strict mobility restrictions were enforced across the country, with very few exceptions between week 12 and week 20, which reduced mobility significantly (Jiang, Laranjo, and Thomas 2022). The policies were then relaxed in most areas from mid-May (week 20). This provides a natural setting for us to examine how metropolitan areas responded to such policies and how persistent the policy impacts were.

Figure 1 shows that the number of delineated units---aggregated municipalities, plus remaining individual municipalities---increased in week 12 and reached a steady level from week 13 through week 17 regardless of the threshold used in the delineation. Specifically, the count increased from 291 in week 2 to 549 in week 15 under the 4% threshold and from 210 to 420 under the 3% threshold. This is primarily driven by the strict community quarantine policies, which reduced cross-jurisdiction commute disproportionately than intra-jurisdiction commute. The commute data reveals that within-city commutes accounted for 80% of flows on average in week 2. The percentage rose to an average of 86% in week 15. Flows between 206,487 inter-city Origin-Destination (OD) pairs were observed in week 2, whereas only 95,793 OD pairs were observed in week 15. As a result, the pre-pandemic MAs were fragmented into smaller aggregations and individual municipalities when the same algorithm and threshold were applied.

Figures 5a–5c show the number of MAs with a total population greater than 1 million, the number of cities and municipalities they contained, and the sum of population across these MAs, respectively, by week. Clear patterns emerge from these charts.

Compared to the pre-pandemic weeks, there were fewer large MAs, and the remaining large MAs encompassed much fewer cities and municipalities and host a substantially smaller population during the weeks when strict quarantine policies were in place. This holds true for different thresholds from 3% to 6%.¹⁰

The middle panels of Figures 2a-2c further illustrate that the large MAs became fewer and smaller in the Philippines under the restriction policies. Take the MA associated with Metro Manila as an example. In week 15, it turned into several smaller MAs (although some still above 1 million population) plus a number of individual municipalities. Even the official Metro Manila, which has been highly integrated for a long history, appeared fragmented. This is somehow expected as commutes between the official Metro Manila and surrounding municipalities as well as those between cities within the official Metro Manila were largely prohibited.

Did the MAs bounce back when the mobility restrictions were relaxed across most of the country after week 20? The answer is positive. The delineation results for week 27 to week 40 suggest that the recovery was quite speedy. Figure 1 shows that the number of delineated units decreased to a stable level around week 28 across different thresholds.¹¹ The recovery was not yet 100% percent as the number of delineated units was still higher than before the pandemic. This was most likely because the restrictions were only relaxed rather than abandoned by the time.

Furthermore, Figures 5a–5c show that the number of MAs above 1 million population, the number of constituent cities and municipalities, and total population across

¹⁰ The exception is the number of MAs under the 3% threshold, which remains stable in the high restriction weeks. However, these metropolitan areas became smaller in general in terms of number of LGUs or population aggregated.

¹¹ We do not present results for weeks 20 through 26 due to concern about data validity for those weeks. Nonetheless, they likely represented a short transition period as the counts in week 27 were higher than those of week 28.

the large MAs all went up in this third phase. Under the 4% threshold, these large metropolitan areas recovered to host over 42 million residents in 247 cities and municipalities in week 37, which equals 76% and 65%, respectively, of the pre-pandemic level.

The right-hand side panels of Figures 2a–2c visualize the recovery of the MAs in three island groups in week 37. There are clearly more and bigger large MAs than in week 15. On the other hand, some MAs, such as the one with Metro Manila, remained fragmented. Some, such as the one with Iloilo City, were smaller, with a few municipalities missing compared to the pre-pandemic agglomeration, and some MAs, such as the one with Metro Cebu, stayed the same as in week 15. The latter is probably because the reduced domestic mobility restriction did not help much with tourism, which Cebu relies on.

Unfortunately, we lack access to post-pandemic data reflecting the complete removal of mobility restrictions. Nevertheless, based on the available findings, we have confidence in asserting that metropolitan areas in the Philippines demonstrate considerable resilience in the face of mobility restriction policies implemented to combat contagious diseases. The impact of these policies on urban agglomerations appears to be transient rather than enduring. Upon the lifting of restrictions, the market forces resume their role, facilitating spatial connectivity among people and allowing people to return to work.

6. Driving Factors for Metropolitan Area Formation

The dynamics of MAs in the Philippines during the pandemic offer a unique natural setting to explore the forces that drive the formation of these urban agglomerations and underlie

their resilience. Leveraging available delineation results, we employ logit regressions to examine what characteristics contribute to the separation of cities and municipalities from their original MAs following the outbreak of the pandemic. Secondly, we investigate the factors pivotal in prompting certain cities and municipalities to rejoin the MAs as quarantine policies subside.

We restrict the sample to all cities and municipalities within MAs with a total population exceeding 0.5 million in week 2, and excluding the core cities, resulting in $n=714$. Regarding the first inquiry, we designate the dependent variable as follows: ‘*Separate*’ = 1 if a city or municipality is affiliated with an MA featuring a distinct core city in week 2 and week 15, and 0 otherwise. This analysis contrasts cities and municipalities that experienced separation from their respective MAs by week 15 with those that remained integrated with them.

For the second investigation, we confine the sample to only the separated cities and municipalities (associated with MAs featuring different core cities in week 2 and week 15), resulting in $n=411$. The dependent variable is defined as follows: ‘*Rejoin*’ = 1 if a city or municipality belongs to an MA with a distinct core city in week 2 and week 15, and to MAs with the same core city in week 2 and 37, and 0 otherwise. This analysis compares cities and municipalities that experienced separation by week 15 and later reintegration into their original MAs by week 37, with those that remained separate throughout week 37.

Specifically, the logit model we estimate is:

$$\ln \frac{p}{1-p} = x' \beta$$

where p is the probability that '*Separate*' =1 or '*Rejoin*' =1, and x is the vector of explanatory variables under examination, including: (i) the log of population from the 2020 census, gauging the size of the city or municipality; (ii) the log of the straight-line distance between the city or municipality and the core city of week 2, capturing proximity; (iii) an indicator denoting whether the city or municipality and core city of week 2 belong to the same province, reflecting the influence of administrative divisions; (iv) road densities (kilometers per capita) categorized by road class, measuring accessibility; and (v) employment shares by sector in the core city of week 2, capturing the labor market composition of the core city.

Furthermore, the regressions control for the stringency of mobility restriction policies in the analyzed city or municipality and in the core city with two indicators, each set to 1 if more stringent policies (i.e., enhanced community quarantine (ECQ) and modified enhanced community quarantine (MECQ)), were implemented in week 15. Due to minimal variation in policies in week 37, a similar indicator for week 37 is omitted from the regressions.

A key channel through which urban agglomeration enhances productivity is to improve labor market matching (Duranton and Puga 2004, Dauth et al. 2022). It stands to reason that the extent of dissimilarity or complementarity among labor markets across various spatial units within an MA correlates with the potential of that MA for enhancing job matching. We assess labor market complementarity between each city or municipality and its associated core city of week 2 using correlation coefficients, Euclidean distance,

and Manhattan distance between the sectoral employment shares of the two cities.¹² Lower correlation coefficients and greater Euclidean and Manhattan distances suggest higher complementarity. Each of these variables is included in our regressions. The results could shed light on the significance of labor market matching mechanisms in shaping metropolitan area formation.

The results of the logit regression are presented in Table 3, where Columns 1–3 analyze the factors influencing the fragmentation of metropolitan areas. Our findings indicate that more stringent mobility restriction policies, larger cities and municipalities located farther from core cities, and those with limited road accessibility (characterized by fewer high-grade roads and more residential roads per capita) are associated with an increased likelihood of separation from the metropolitan areas. Moreover, core cities within metropolitan areas with a higher concentration of hospitality and recreation employment, and a lower share of transport, work-from-home (WFH)-friendly tertiary, utility, and agriculture employment prior to the pandemic, or adopting stricter quarantine measures after the outbreak of COVID-19, are more prone to losing their metropolitan members. On the other hand, factors, such as the municipality and core city belonging to the same province or the degree of similarity between the two labor markets, have no significant impact on the likelihood of separation.

Columns 4–6 explore the factors driving the reunion of cities and municipalities with their original MAs. After the relaxation of mobility restrictions, cities and municipalities that are in closer proximity to, or share the same province as, the original core cities

¹² The Euclidean distance is calculated as $d^E = \sqrt{\sum_i^n (C_i - P_i)^2}$, and the Manhattan distance is calculated as $d^M = \sum_i^n |C_i - P_i|$, where C_i is employment share of sector i in the core city and P_i is employment share of sector i in the municipality of interest.

exhibit a higher propensity to rejoin the MA. While road accessibility shows a positive effect on rejoining, the estimates are not precise for inference. Interestingly, core cities with a higher proportion of tertiary employment prior to the pandemic are less likely to gain back their metropolitan members.

Furthermore, controlling for the labor market composition of the core city, our analysis reveals that municipalities are more inclined to rejoin the MAs when their labor markets differ more significantly from those of their core cities. This is evidenced by positive and statistically significant coefficient estimates for Euclidean distance and Manhattan distance between the two labor markets, along with negative, though insignificant, estimates for the correlation coefficient. These findings suggest that MAs in the Philippines function as integrated labor markets, facilitating the matching of labor supply and demand across a broader spatial scope. This reinforces the notion that labor market integration emerges as a critical factor driving the formation and resilience of MAs, especially in navigating shocks that may temporarily fragment the agglomeration.

7. Conclusion

The paper presents the first commuting-based delineation of MAs in the Philippines, achieved through applying a well-established commuting-based methodology to a novel dataset containing nationwide cellphone user flows. Beyond its scholarly contributions, the findings hold relevant implications on urban management and regional development for policymakers in the Philippines and other developing countries.

In the case of the three officially designated MAs, the commuting-based delineation offers fresh insights into their spatial coverage and underscores the need for potential policy adjustment aimed at enhancing agglomeration productivity and urban

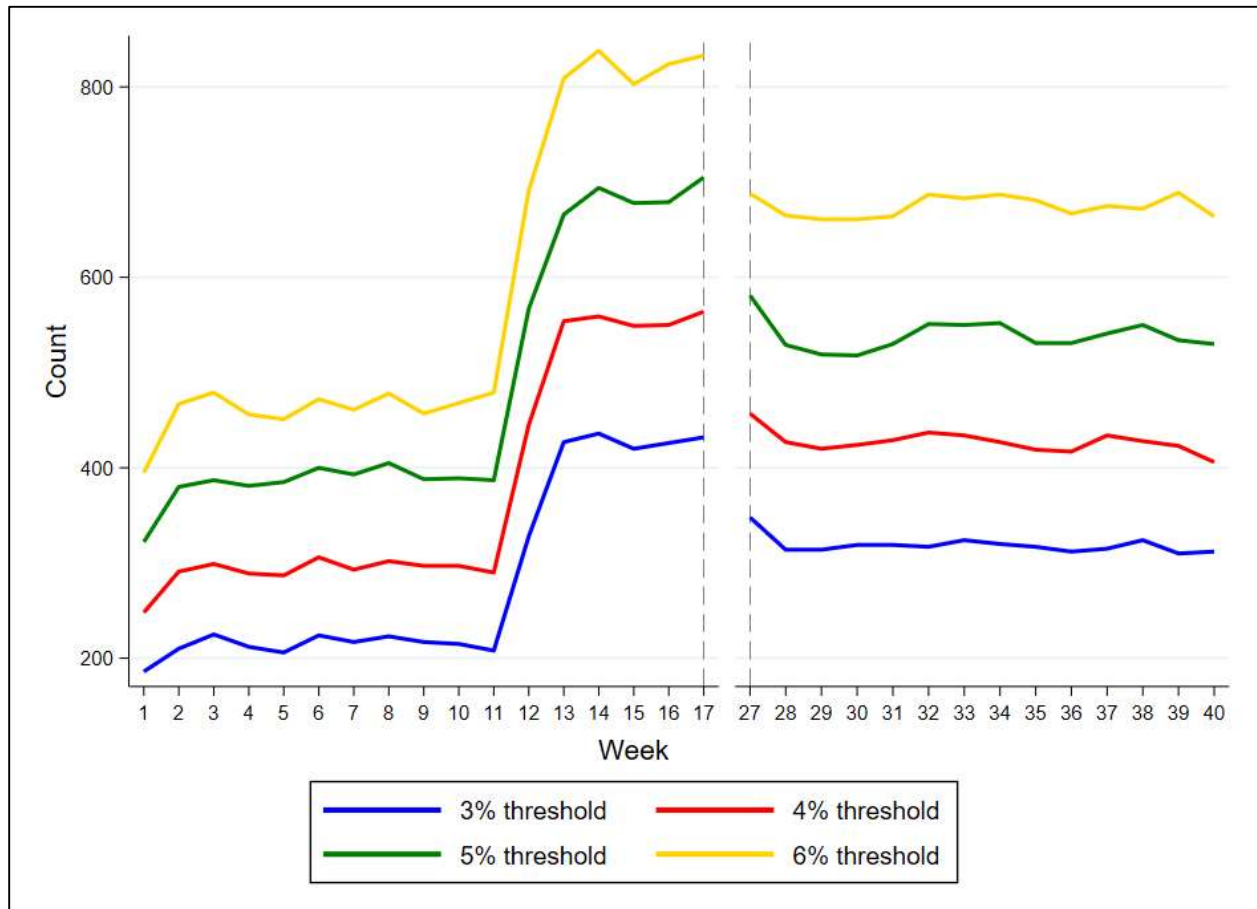
livability. While management and coordination agencies already exist within the official MAs, the economic interconnections have extended well beyond the official boundaries for Metro Manila and Metro Cebu. Consequently, there is a pressing need to extend and scale up existing coordination mechanisms and institutional arrangements to encompass the de facto larger urban agglomerations. As for Metro Davao, the key challenge lies in fostering greater integration with surrounding cities and municipalities within its official scope.

Furthermore, we identified a number of large MAs comprising hundreds of cities and municipalities, with many of them crossing the administrative boundaries of provinces. Official recognition and coordination are missing for them, although they have been acting as engines of growth in the country. To maximize the agglomeration benefits and mitigate friction costs, it would be necessary to synchronize policies, such as urban planning and infrastructure development, across the LGUs within these MAs. Institutional arrangements to facilitate effective communication and collaboration among city, municipality, and provincial authorities may be essential to achieve concerted policies. Infrastructure projects that strengthen connectivity across municipal and provincial borders or between islands with a high volume of daily commute flows could be prioritized as they are likely to yield substantial social returns.

Employment plays a critical role in economic development and improving welfare for people in developing countries. In the context of the Philippines, we find that large MAs feature integrated labor markets that provide job opportunities and support better matching between workers and firms. Therefore, fostering the development of MAs should be deemed a priority within the development agenda of such countries.

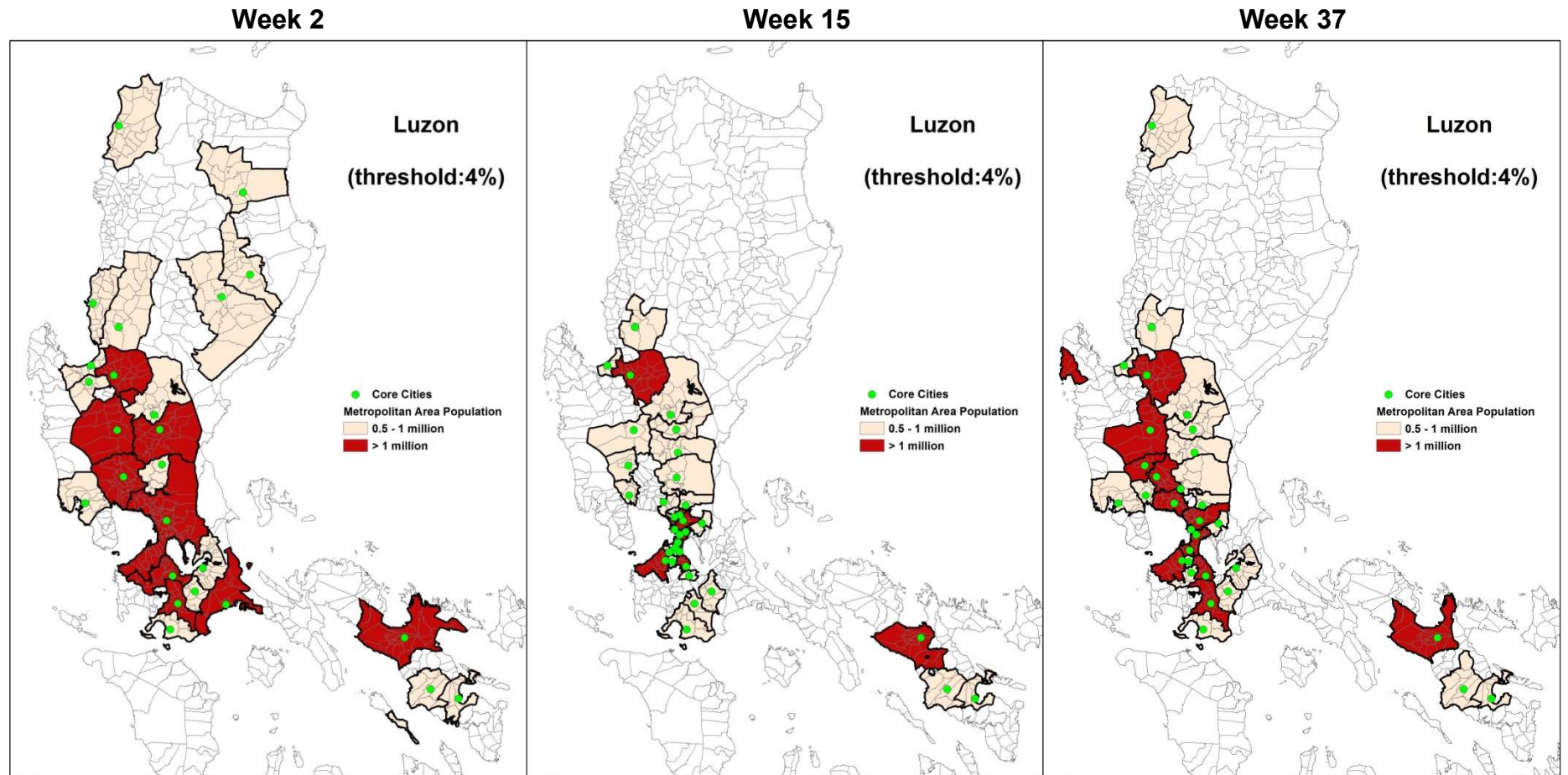
FIGURES AND TABLES

Figure 1: Number of Delineated Metropolitan Areas and Individual Municipalities by Week



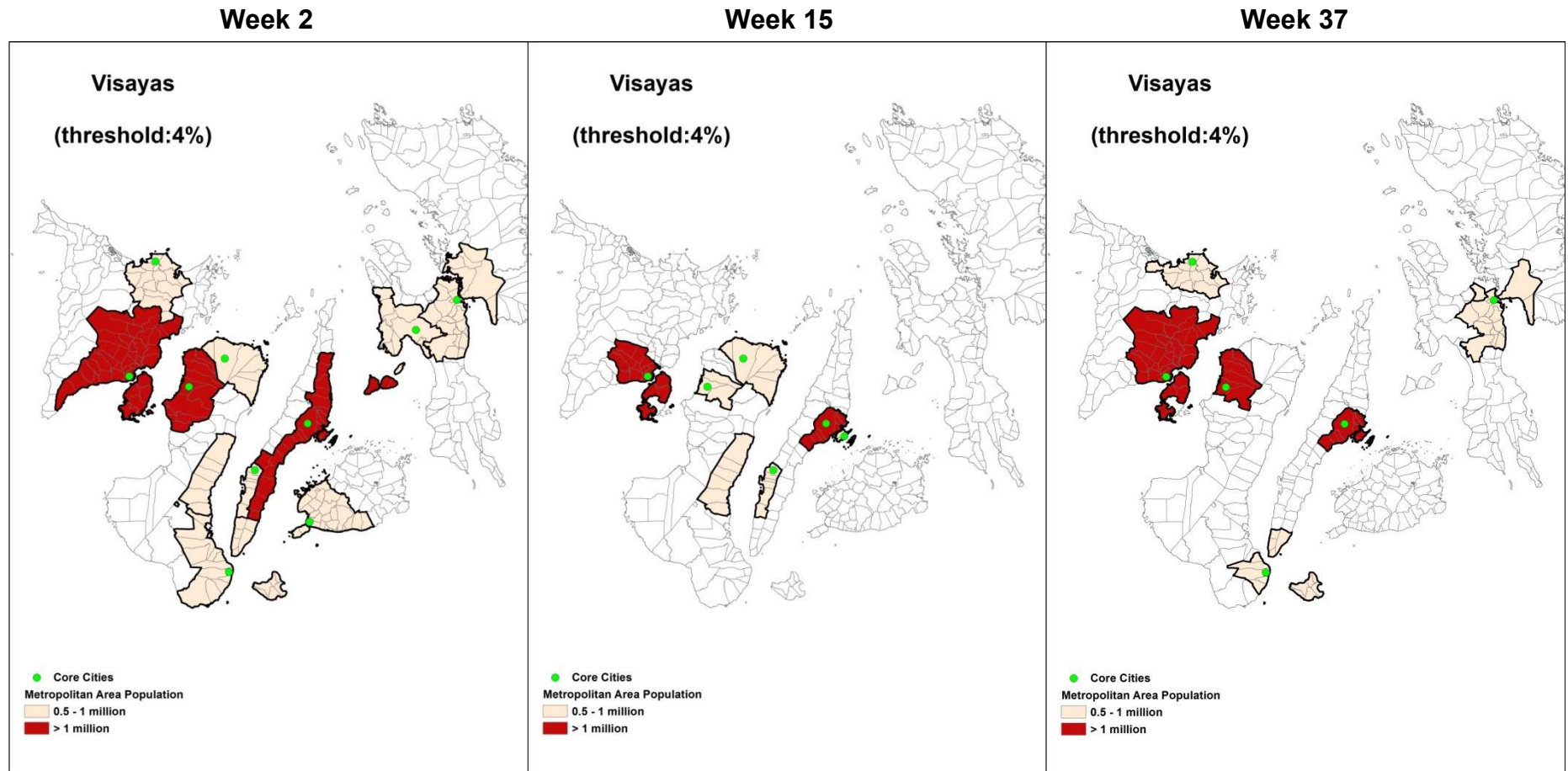
Source: Authors' calculations.

Figure 2a: Metropolitan Areas with a Total Population Greater than 500,000 in Luzon at 4% Threshold



Source: Authors.

Figure2b: Metropolitan Areas with a Total Population Greater than 500,000 in Visayas at 4% Threshold



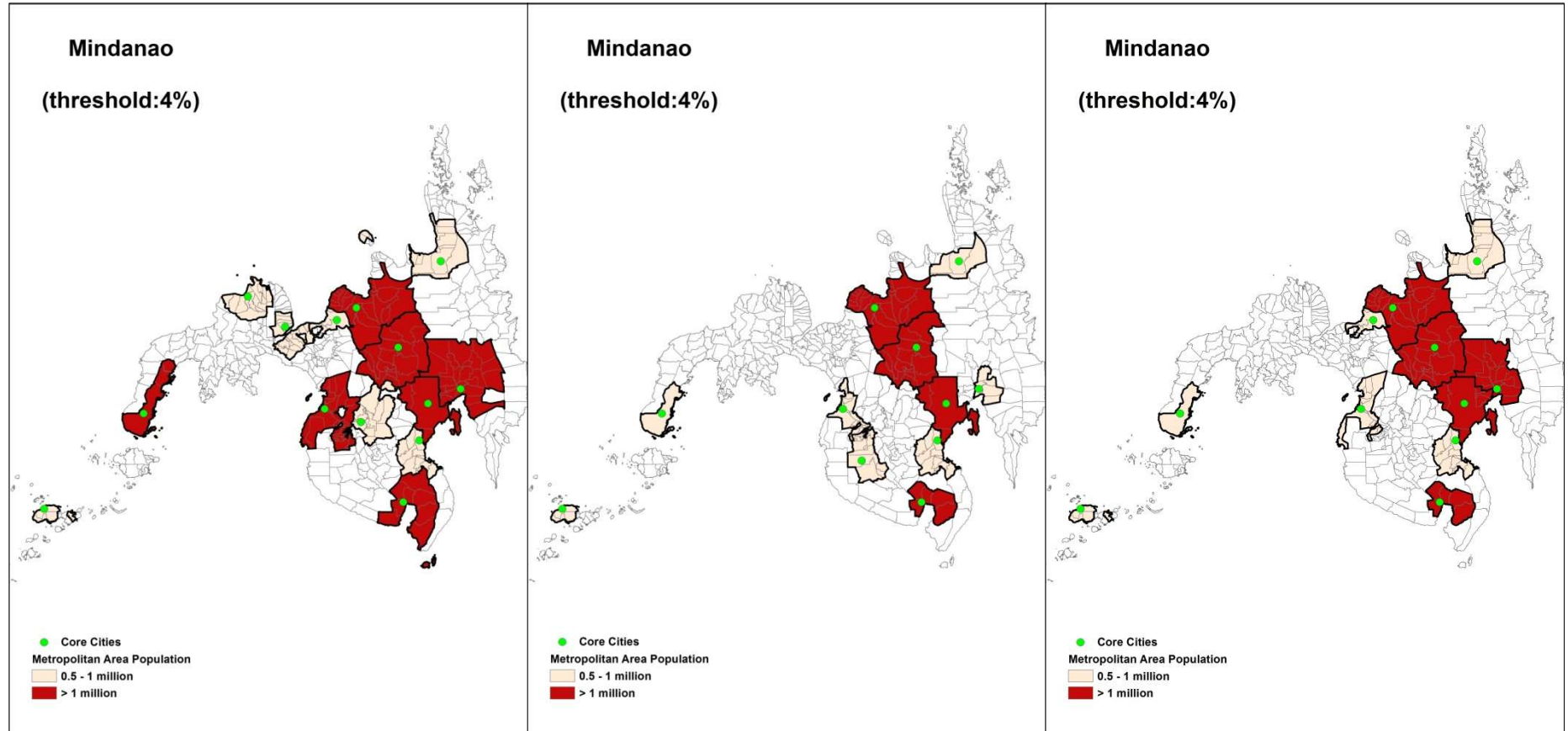
Source: Authors.

Figure 2c: Metropolitan Areas with Total Population Greater than 500,000 in Mindanao at 4% Threshold

Week 2

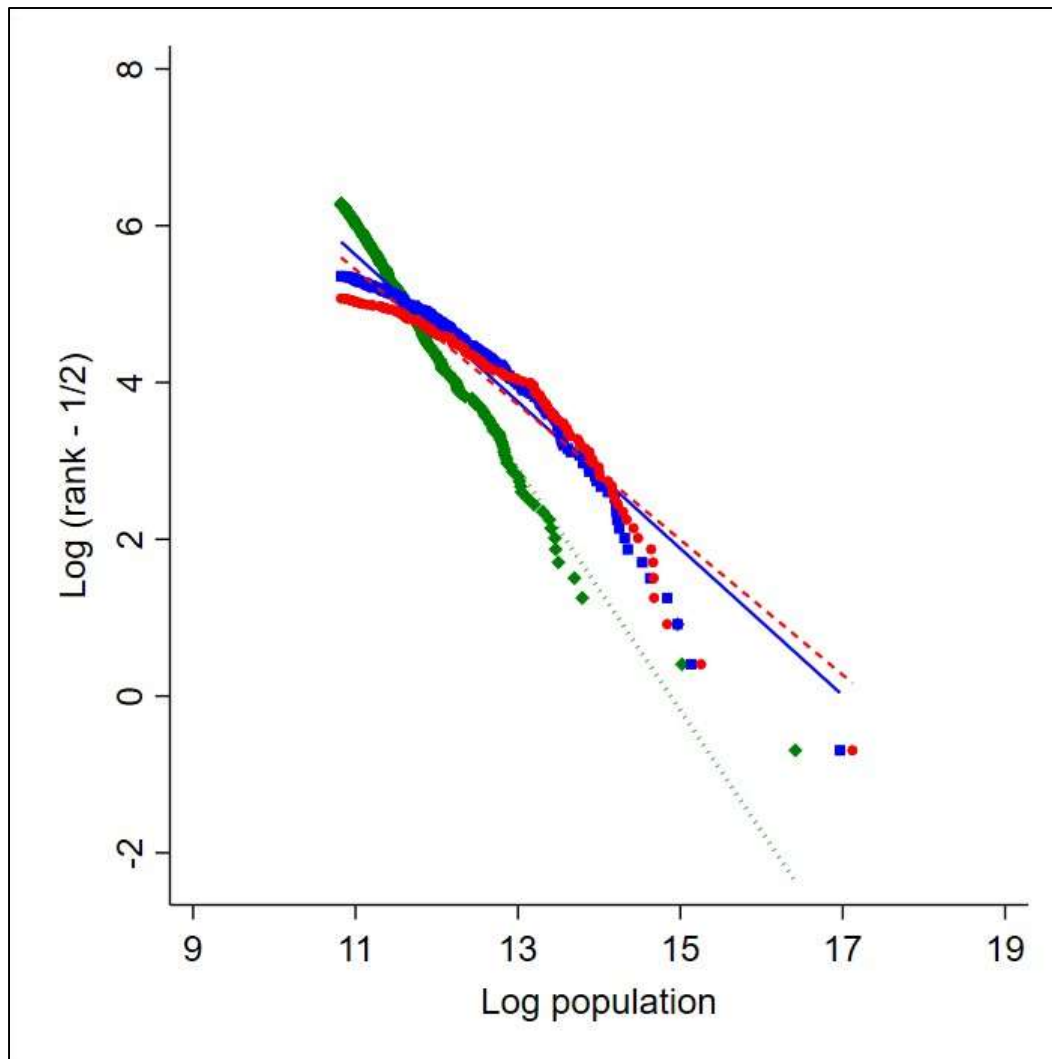
Week 15

Week 37



Source: Authors.

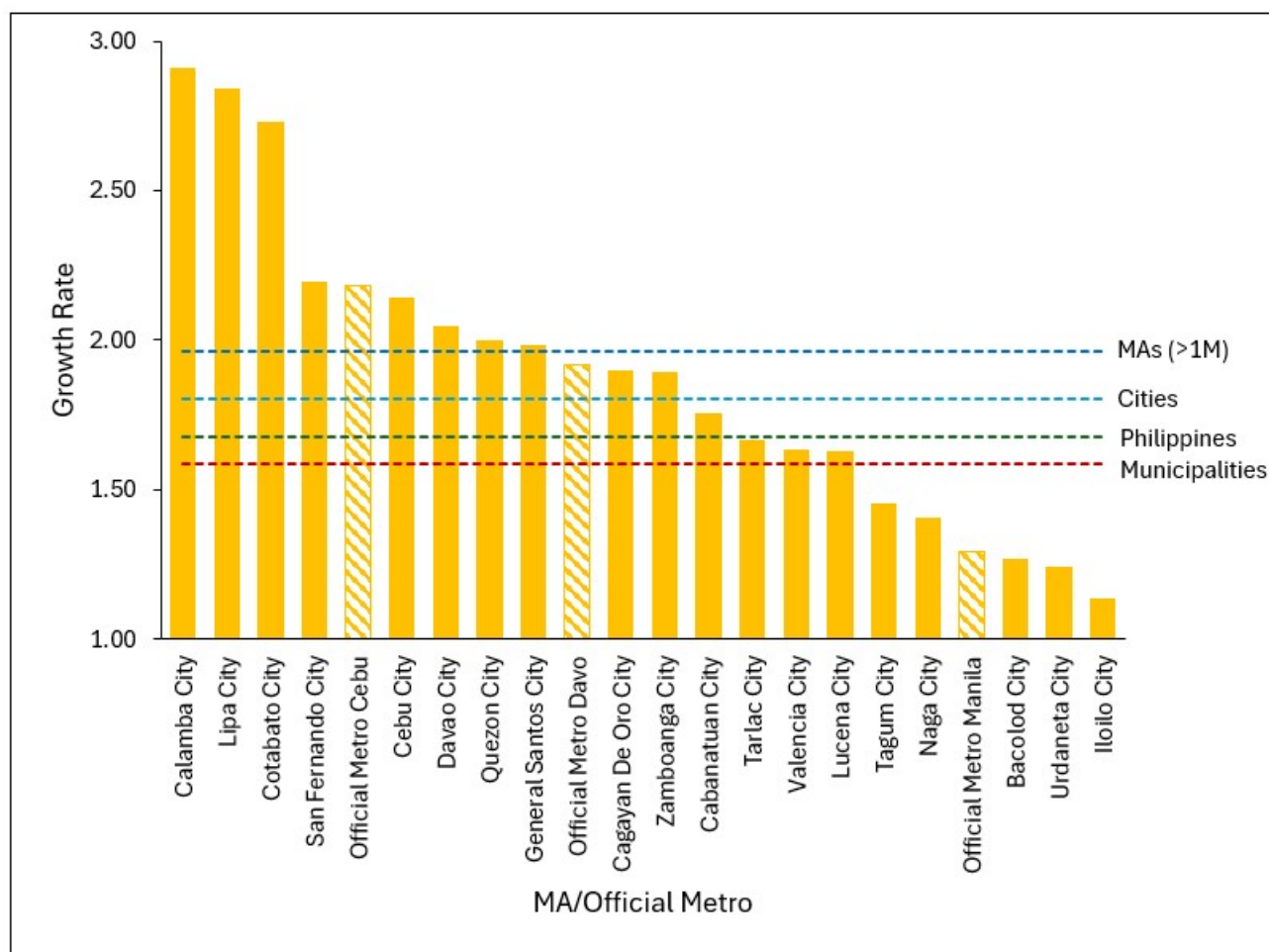
Figure 3: Zipf's Law for Urban Systems in the Philippines



Notes: The green diamonds represent 3 official metropolitan areas (MAs) and administratively defined cities and municipalities (n=534) and the green dotted line is the associated regression line with slope=-1.543 (se=0.008) and R-squared=0.987. The blue squares represent MAs delineated using the preferred 4% commuting threshold (n=213) and the blue plain line is the associated regression line with slope=-0.936 (se=0.016) and R-squared=0.939. The red dots represent MAs delineated using a 3% threshold (n=160) and the red dashed line is the associated regression line with slope=-0.862 (se=0.021) and R-squared=0.912.

Source: Authors' calculations with a minimum 2020 population threshold of 50,000.

Figure 4. Annual Average Population Growth of the Delineated and Official Metropolitan Areas, 2010–2020

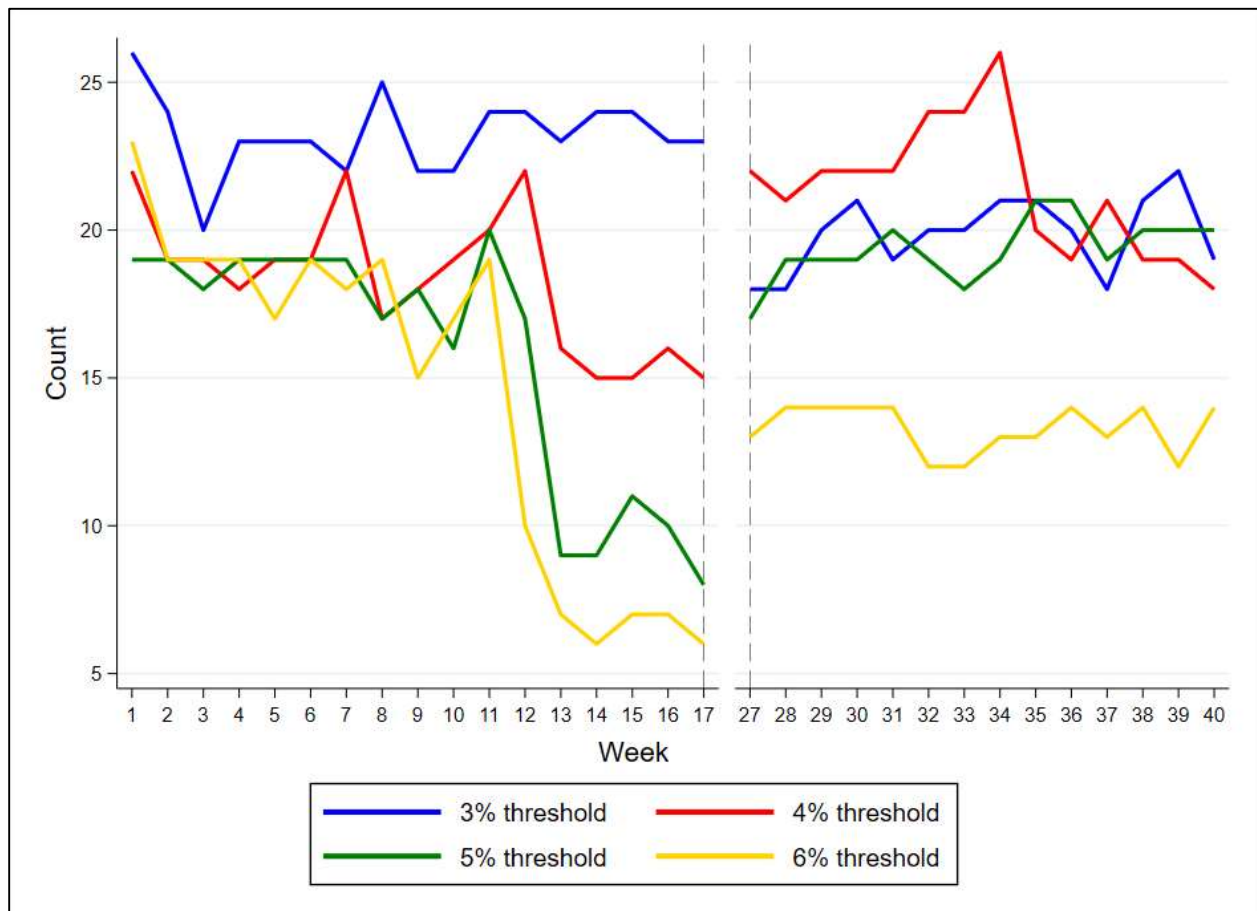


M = million, MA = metropolitan area.

Notes: The annual growth rate for the Philippines, all the cities and all the municipalities are 1.68, 1.81, and 1.59, respectively. Across the 19 delineated MAs with population greater than 1 million, the growth rate is 1.96. The growth rates of official Metro Manila, Metro Cebu and Metro Davao (shaded bars) are 1.30, 2.18, and 1.92, respectively.

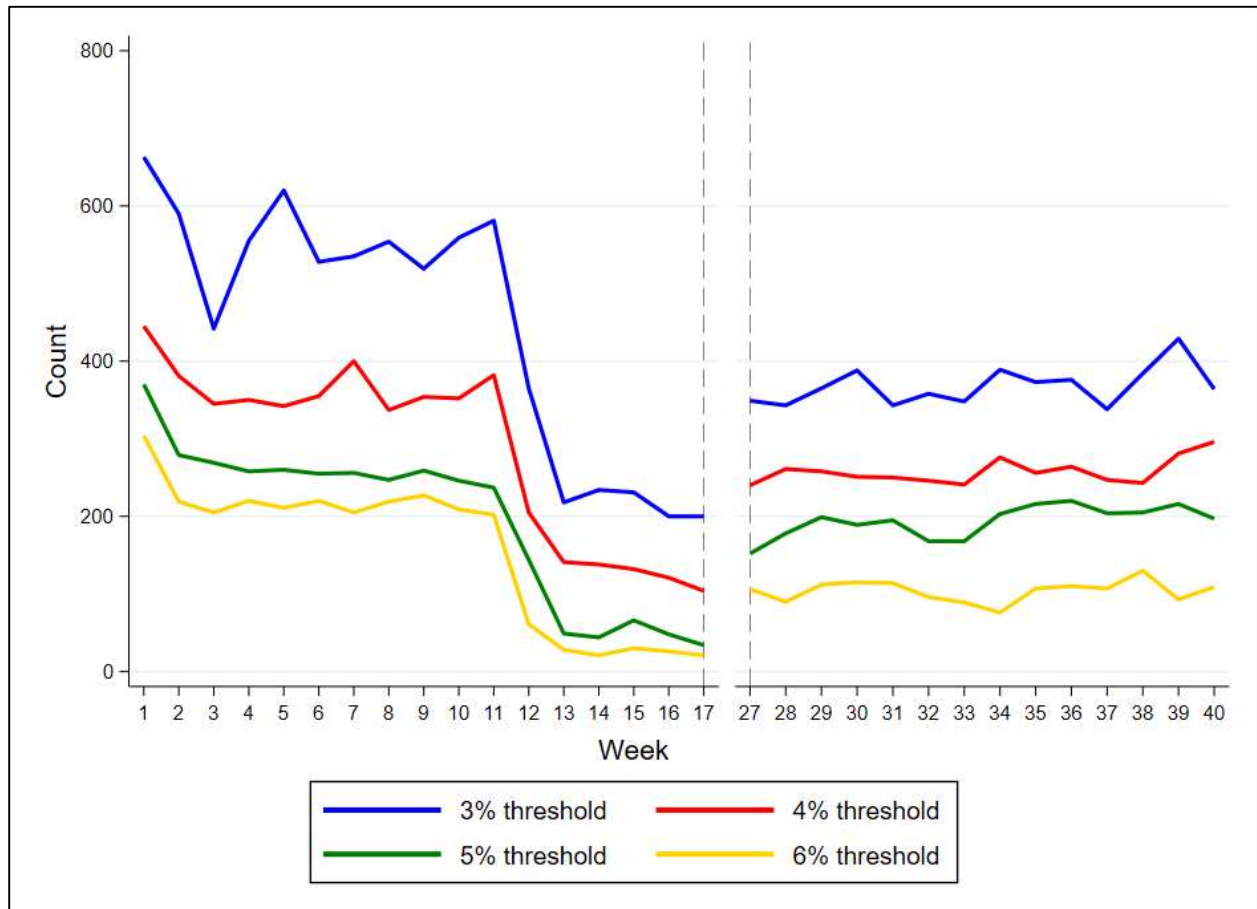
Source: Authors' calculations.

Figure 5a: Number of Metropolitan Areas with a Total Population Greater than 1 Million, by Week



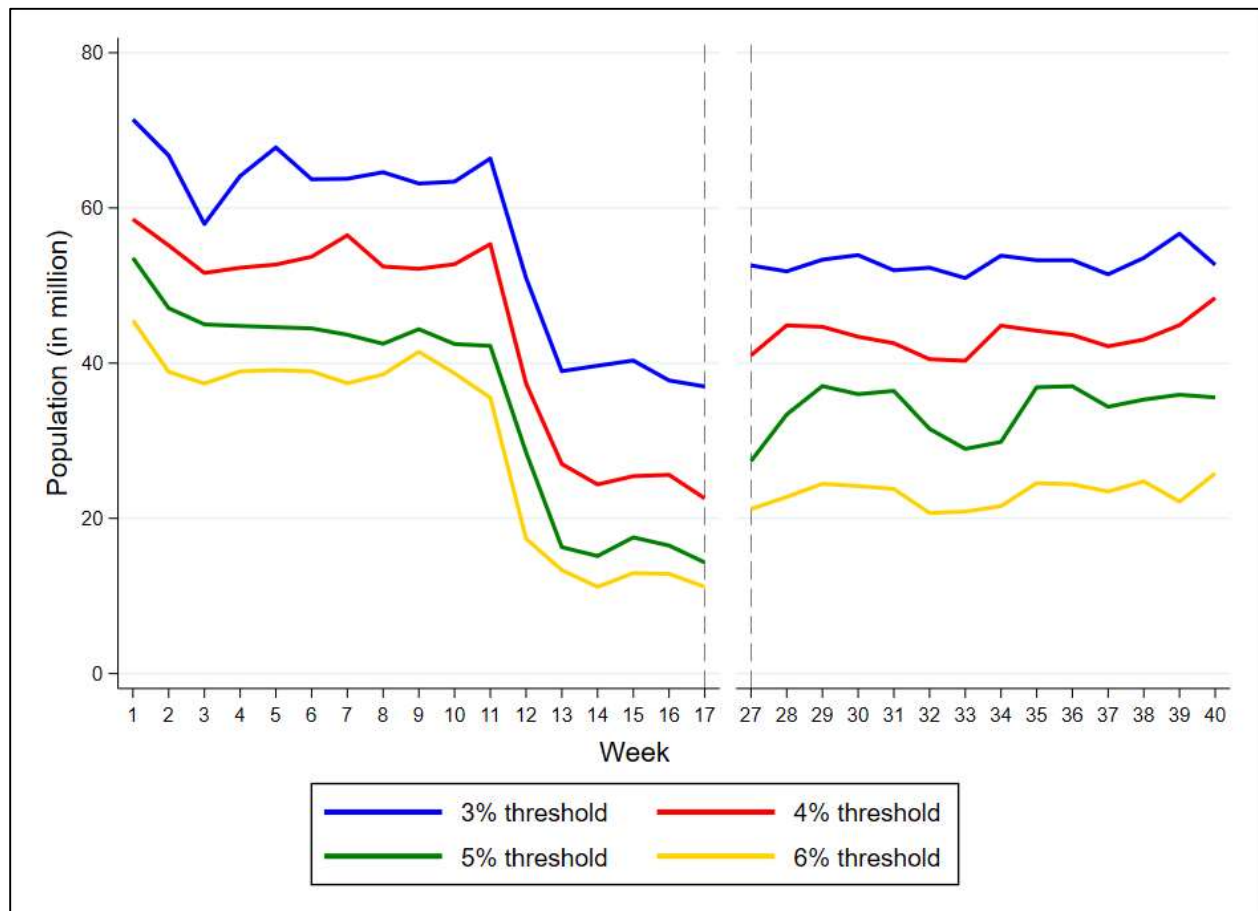
Source: Authors' calculations.

Figure 5b: Number of Cities and Municipalities in Metropolitan Areas with a Population Greater than 1 Million, by Week



Source: Authors' calculations.

Figure 5c: Sum of Population in Metropolitan Areas with a Population Greater than 1 Million, by Week



Source: Authors' calculations.

Table 1: Pre-pandemic Metropolitan Areas in the Philippines with a Population above 1 Million

Core City	Island Group	Metropolitan Area Population	Number of Cities and Municipalities	Number of Provinces	Core City Population	Population Growth Rate, 2010–2020 (%)
Quezon City	Luzon	23,354,180	63	7	2,960,048	2.00
Cebu City	Visayas	3,737,955	25	1	964,169	2.14
Calamba City	Luzon	3,158,807	18	3	539,671	2.91
San Fernando City	Luzon	2,781,140	21	1	354,666	2.20
Iloilo City	Visayas	2,257,156	38	2	457,626	1.14
Davao City	Mindanao	2,045,403	4	3	1,776,949	2.05
Tagum City	Mindanao	1,711,421	20	2	296,202	1.45
Cagayan De Oro City	Mindanao	1,645,418	21	2	728,402	1.90
Tarlac City	Luzon	1,543,135	18	2	385,398	1.66
Cotabato City	Mindanao	1,503,028	26	3	325,079	2.73
Bacolod City	Visayas	1,490,095	12	1	600,783	1.27
Cabanatuan City	Luzon	1,483,672	20	1	327,325	1.76
Naga City	Luzon	1,454,918	26	1	209,170	1.41
General Santos City	Mindanao	1,341,422	8	3	697,315	1.99
Lipa City	Luzon	1,227,549	11	1	372,931	2.84
Valencia City	Mindanao	1,165,914	15	2	216,546	1.63
Urdaneta City	Luzon	1,141,599	21	2	144,577	1.24
Zamboanga City	Mindanao	1,067,306	3	2	977,234	1.89
Lucena City	Luzon	1,058,152	11	2	278,924	1.63
Total		55,168,270	381	33	12,613,015	1.96

Note: The metropolitan areas are delineated using pre-pandemic week 2 data and 4% threshold.

Sources: Philippine Statistics Authority and authors' calculations.

Table 2: Comparison of Three Official Metropolitan Areas and Their Delineated Counterparts

	Metro Manila	Metro Cebu	Metro Davao
Official definition			
Number of cities and municipalities	17	13	15
Highly urbanized cities	16	3	1
Component cities	0	4	5
Municipalities	1	6	9
Land area (km ²)	619.5	1,062.9	6,492.8
Population (2020)	13,484,462	3,165,799	3,339,284
Population density (person/km ²)	21,765	2,979	514
Delineated MAs (threshold=4%)			
Number of cities and municipalities	63	25	4
Highly urbanized cities	16	3	1
Component cities	10	4	1
Municipalities	37	18	2
Land area (km ²)	4864.9	2465.2	3758.0
Population (2020)	23,354,180	3,737,955	2,045,403
Population density (person/km ²)	4,801	1,516	544
Delineated MAs (threshold=3%)			
Number of cities and municipalities	86	31	6
Highly urbanized cities	16	3	1
Component cities	16	4	2
Municipalities	54	24	3
Land area (km ²)	6697.4	3240.0	4175.3
Population (2020)	27,213,604	4,219,271	2,336,651
Population density (person/km ²)	4,063	1,302	560

MA = metropolitan area, km² = square kilometer.

Sources: Philippine Statistics Authority and authors' calculations.

Table 3: Logit Regressions on Drivers for Fragmentation and Recovery of Metropolitan Areas

Variable	(1) Separate	(2) Separate	(3) Separate	(4) Rejoin	(5) Rejoin	(6) Rejoin
Log of municipality population (2020 CPH)	0.155* (0.087)	0.168* (0.089)	0.170* (0.093)	-0.047 (0.104)	0.014 (0.107)	0.028 (0.110)
Log of straight-line distance of municipality to core (in km) at 4% threshold	1.834*** (0.152)	1.834*** (0.152)	1.834*** (0.152)	-1.001*** (0.199)	-1.036*** (0.201)	-1.041*** (0.202)
1 if municipality is in ECQ/MECQ in week 15	-0.040 (0.307)	-0.049 (0.308)	-0.049 (0.308)	1.369* (0.743)	1.405* (0.750)	1.325* (0.734)
1 if core city is in ECQ/MECQ in week 15	0.504 (0.314)	0.518* (0.315)	0.519* (0.315)	-1.362* (0.760)	-1.443* (0.767)	-1.350* (0.750)
1 if municipality and core are in same province	-0.029 (0.150)	-0.017 (0.151)	-0.017 (0.150)	0.758*** (0.199)	0.789*** (0.199)	0.776*** (0.198)
Road density						
Highway	1,818.721 (1,378.237)	1,808.431 (1,379.522)	1,813.016 (1,379.792)	2,287.130 (1,428.038)	2,310.415 (1,433.721)	2,367.031* (1,431.187)
Primary	-362.540* (200.173)	-365.769* (199.513)	-365.884* (199.573)	373.492 (280.081)	415.403 (279.309)	393.834 (278.153)
Secondary	-583.765** (246.195)	-590.036** (245.808)	-590.779** (245.880)	100.180 (349.708)	154.471 (354.003)	110.670 (352.173)
Tertiary	-333.459*** (113.988)	-336.355*** (114.385)	-336.228*** (114.296)	226.482 (144.620)	184.353 (146.107)	192.136 (146.351)
Trunk	-419.471 (286.219)	-417.650 (285.543)	-418.113 (285.343)	408.695 (304.101)	493.672 (304.342)	478.240 (304.328)
Link	647.785 (1,176.348)	679.806 (1,179.014)	682.049 (1,180.009)	-4,624.485 (3,245.343)	-4,548.334 (3,261.503)	-4,486.368 (3,242.868)
Residential	261.693*** (89.470)	258.197*** (89.202)	258.431*** (89.220)	-457.627*** (112.055)	-446.542*** (111.856)	-437.586*** (111.943)
Employment share by sector in core city						
Manufacturing	- -	- -	- -	- -	- -	- -
Primary	-10.440*** (2.261)	-10.272*** (2.255)	-10.271*** (2.254)	-3.947 (3.846)	-3.468 (3.842)	-3.451 (3.857)
Power, Utilities, Construction	-4.553*** (1.649)	-4.617*** (1.644)	-4.627*** (1.649)	4.167 (3.189)	3.500 (3.203)	3.353 (3.213)
Trade, Transport	-5.521*** (1.079)	-5.359*** (1.076)	-5.354*** (1.083)	-1.523 (1.176)	-1.111 (1.179)	-0.997 (1.197)
Hospitality, Recreation	3.963** (1.949)	4.267** (1.923)	4.259** (1.910)	1.019 (2.764)	1.688 (2.743)	1.247 (2.718)
WFH-friendly tertiary	-3.182*** (1.105)	-3.316*** (1.087)	-3.319*** (1.089)	-2.767** (1.259)	-2.804** (1.209)	-2.776** (1.206)
Non-WFH-friendly tertiary	-1.763 (1.142)	-1.863* (1.130)	-1.876* (1.137)	-3.743** (1.617)	-3.343** (1.626)	-3.499** (1.621)
Sector employment share similarity measures between municipality and core at 4% threshold						
Correlation	0.169 (0.309)			-0.354 (0.395)		
Euclidean distance		0.056 (0.470)			1.451** (0.598)	
Manhattan distance			0.035 (0.271)			0.768** (0.348)

Continued on the next page

Variable	(1) Separate	(2) Separate	(3) Separate	(4) Rejoin	(5) Rejoin	(6) Rejoin
Constant	-4.904*** (1.360)	-4.999*** (1.475)	-5.021*** (1.532)	4.698*** (1.522)	3.163* (1.662)	2.969* (1.726)
Observations	714	714	714	411	411	411

CPH = census of population and housing, ECQ = enhanced community quarantine, km = kilometer, MECQ = modified enhanced community quarantine, WHF = work-from-home.

Notes: ***, **, * significant coefficients at 1%, 5%, 10%.

Values in parentheses are standard errors.

Source: Authors' calculations.

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Metropolitan Area Delineation and Resilience Under a Public Health Crisis

Evidence from the Philippines

This paper delineates and examines the dynamics of metropolitan areas in the Philippines during the COVID-19 pandemic. The study identifies several large metropolitan areas not officially recognized, and different spatial extents for the three officially designated metropolitan areas prior to the pandemic. The largest metropolitan areas grew faster than urban areas and the country as a whole. Metropolitan areas contracted or fragmented under strict mobility restrictions but rebounded swiftly as restrictions eased. Proximity, administrative boundaries, accessibility, and labor market complementarity play important roles in metropolitan areas formation.

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