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Small and medium cities and development of Mexican rural areas

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ABSTRACT

Like the rest of Latin America, Mexico is a highly-urbanized country. Yet rural populations, geographies and economic activities continue to play a significant role in national development, while there are persistent and large rural-urban inequalities in well-being and opportunities. Promoting rural-urban linkages has been proposed as a strategy to reduce spatial inequalities, but there is much academic and policy debate about whether urban development has positive (spread) or negative (backwash) effects on rural development. This could translate into synergistic or predatory urban-rural linkages. This study examines how proximity to cities, and population and per capita income in cities, affect population growth and welfare in rural places in Mexico. Using data for 2000 and 2010, our findings include: (a) 75% of rural people live within 90 min of an urban area, and 60% within 60 min; (b) proximity to a city increases rural population growth and welfare; (c) adverse (backwash) effects on rural areas due to increases in urban per capita income are very small and of no economic significance; (d) cities with populations in the 350,000–500,000 range appear to have more positive effects on rural areas than smaller or larger cities; (e) rural localities interact with multiple urban places simultaneously.

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1. Introduction

Latin America[1] is one of the most urbanized regions of the world, with national urbanization rates ranging between 50% and 95% (UNDESA, 2014). Urbanization in the Latin American region is as high in North America and higher than in Europe (UNDESA, 2014).

Despite common perceptions, however, Latin American urbanization is quite decentralized in thousands of cities and towns of fewer than 500,000 inhabitants. Four of the five largest economies and 11 of the 19 Latin American countries have urban primacy rates below the global average, with Brazil and Mexico leading the trend (12% and 21% primacy rates, respectively; UNDESA (2014)). The growth of the very large megalopolises, such as Mexico City and Sao Paulo, stabilized many years ago, while rural populations continue to drop, not only in relative terms, but also in absolute numbers since 2000. Populations and possibly economies are now growing faster in medium-size cities than in larger urban conglomerations.

Since the early 2000s, a region-wide program involving more than 30 partners has been studying why certain sub-national regions, defined as territories (Schejtman & Berdegué, 2003), show development dynamics that have led to *socially inclusive economic growth* (i.e., economic growth with a reduction of poverty *and* inequality). An analysis of more than 10,000 municipalities or their equivalents in 10 countries showed that only 12% experienced socially inclusive economic growth between the mid-1990s and mid-2000s (Modrego & Berdegué, 2015). Case studies for 20 territories dispersed throughout the region showed that the presence of, and linkages with, nearby cities appear to be one of the key factors explaining the differences in territorial social inclusiveness and economic growth (Berdegué, Carriazo, Jara, Modrego, & Soloaga, 2015). Country-wide studies of decade-long development dynamics of functional territories in Chile, Colombia and Mexico have shown that rural-urban territories (i.e., those in which an urban core is functionally connected, through a dense set of interdependencies, with a number of surrounding rural localities), significantly outperformed purely rural territories in terms of poverty reduction and economic growth, an effect that correlated positively with the size of the urban core (Berdegué, Escobal, & Bebbington, 2015).

There is also a body of literature that studies rural-urban interactions in developed countries. Using models that link non-metropolitan to metropolitan areas in the United States of America between 1950 and 2000, it was found that non-metropolitan areas farther from higher tiered urban areas had lower population growth. This negative effect increased over time, perhaps because

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[1] We refer to the 19 Spanish- and Portuguese-speaking countries in the Western hemisphere.

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of the centralizing effect of new technology in a mature USA urban system (Partridge, Rickman, Ali, & Olfert, 2008). Using similar models, Ganning, Baylis, and Lee (2013) found that USA non-metropolitan areas are influenced by multiple cities, rather than only the nearest city; this points to a need for collaborative, inter-urban public policy approaches to non-metropolitan development. Behind these findings lies the fact that proximity to cities provides not only markets for goods produced in rural areas, but also opportunities to diversify income sources from non-rural employment (Evans, 1990; De Janvry & Sadoulet, 2001).[2] Non-agricultural rural income is also becoming more important than agricultural income in many parts of Latin America (Reardon, Berdegué, & Escobar, 2001), as in Africa and Asia (Reardon, Taylor, Stamoulis, Lanjouw, & Balisacan, 2000). It is not surprising, then, that distance to urban centers is a constraint on rural development. Wu and Gopinath (2008) found that remoteness was the primary cause of spatial disparities in economic development in the USA, while Christiaensen and Todo (2013),using a cross-country panel data approach for developing countries, found that migration out of agriculture into the "missing middle" (i.e., the rural nonfarm economy and secondary towns) translates into more inclusive growth than agglomeration in megacities.

There is therefore sufficient evidence to suggest that more inclusive economic growth can be promoted by stronger rural-urban relationships. Nonetheless, rural-urban relationships can sometimes be predatory (i.e., when the city grows, its hinterland loses). Balancing the positive and negative effects of rural-urban interactions is difficult under the best of circumstances, and it is particularly important for developing regions where significant rural population and activities co-exist with urban growth. Understanding what types of development dynamics in cities may stimulate growth and improve well-being in surrounding rural areas is a relevant policy and research question.

Mexico is a middle-income country where more than 20% of the population lives in rural areas. There are high levels of both international and domestic (interstate) migration (Soloaga, Lara, & Wendelspiess, 2010). In recent years, population growth has been occurring mainly in medium size cities influenced by the development of new manufacturing industries, the intensification of old ones (mostly *maquiladoras*) and services. The effects of these dynamics on the country's considerable rural areas and populations are not fully understood.

Our research questions are:

1. What effect does living close to a small to medium urban center, compared to a large city, have on rural inhabitants' development opportunities and well-being?
2. What effects do *changes* in small and medium cities have on rural inhabitants' development opportunities and well-being, compared with the effects of changes in large cities?

From a public policy perspective, it is important to assess whether results found for developed countries hold for Mexico. We find that they do, and that rural areas interact with multiple cities simultaneously, not just with the closest one. Moreover, proximity to mid-range cities (i.e., those with a population of between 350,000 and 499,999) offers greater potential for rural development. A rural locality that is close to an urban area with a population of 350,000 or more could experience population growth that is 10 to 18 percentage points higher, over 10 years, than that of a more distant locality. Five additional percentage points could come from population growth in those urban areas (spread effects). Although we also find backwash effects on rural areas from increments in urban per-capita income growth, these are quite small. Population growth in rural areas seems to be driven mainly by changes in population growth in urban areas and by distances to them.

2. Method

To answer the research questions, we first classify Mexican territories into rural, rural-urban and urban. We begin by applying the ArcGIS Network Analyst software to the national road database from Mexico's Secretariat (ministry) of Communications and Transportation and microdata from the 2010 Population Census to compile a matrix of distance and travel time for all rural and urban locations with populations greater than 100 inhabitants. The 50,030 localities in the matrix (including 59 officially-designated metropolitan areas) contain 97% of the country's population.

Mexico's National Urban System (in Spanish, *Sistema Urbano Nacional,* or SUN) includes 384 urban areas with a population exceeding 15,000 inhabitants, while smaller localities are considered rural (SEDESOL, CONAPO, & INEGI, 2012). For our empirical approach, we follow this characterization and define rural localities (RL) as those with fewer than 15,000 inhabitants (Type0 for short) and urban localities (UL) as those with 15,000 or more inhabitants. Several UL are made up of several individual localities that form conurbations (i.e., an aggregation of two or more municipalities that include multiple cities). Thus, the term UL identifies either a single locality or a conurbation. We identify seven types of UL, by population: i) between 15,000 and 49,999 (Type1), ii) between 50,000 and 249,999 (Type2), iii) between 250,000 and 349,999 (Type3), iv) between 350,000 and 499,999 (Type4), v) between 500,000 and less than 1 million (Type5), vi) between 1 and less than 5 million (Type6) and, vii) more than 5 million (Type7).[3]

To answer the research questions, we use as a starting point the work of Partridge, Bollman, Olfert and Alasia (2007) and Partridge et al. (2008). Their models examine how proximity to urban agglomerations affects population growth in hinterland counties. We follow Ganning et al. (2013) modification of those models and adjust them to analyze not only changes in population levels, but also effects on welfare indicators. The working hypothesis is that changes in key variables in a given RL are influenced by changes in the characteristics of *relevant* UL. One key consideration is to identify which are the *relevant* UL for each RL. The approach follows the Central Place Model (CPM) and considers that there is a hierarchy of UL based on the assumption that urban areas with larger populations offer more sets of goods and services than are available in urban locations with smaller populations. Using this approach, if a given RL is closer to, say, a Type3 UL, any influence coming from Type1 or Type2 UL is ignored. We considered this assumption too restrictive and implemented a general version that tests whether the hierarchy implied by the CPM holds.

The general formulation of the econometric approach for these two models is as follows:

$$\%\Delta Y_{2000\ y\ 2010,is} = \propto + \beta DIST_{i\rightarrow T_j} + \gamma GEOG_{i,2000} + \Delta MKT_{T_{j,2000}} + \theta \Delta MKT_{T_{j,2000\ y\ 2010,}} + \sigma_s + \in_{ist},$$

[2] Issues well covered in the literature on urban agglomeration and externalities are also very important in these rural-urban interactions. Reviews are presented, for example, in Berdegué, Carriazo, et al. (2015) and Ganning et al. (2013).

[3] OECD (2013) presents the following classification for OECD countries, including Mexico: *"Small urban areas, with a population below 200 000 people; Medium-sized urban areas, with a population between 200 000 and 500 000; Metropolitan areas, with a population between 500 000 and 1.5 million; Large metropolitan areas, with a population of 1.5 million or more."* To gain a better understanding of how different urban population sizes affect non-urban ones, we use finer categories in this paper.

where Y could be population, housing quality, housing services, average years of schooling or access to health services, for RL i, in state s. Except for population, all are welfare indicators.[4] **DIST** is the travel time from RL i to the different UL Types (1 to 7), **GEOG** is a vector that contains lagged i variables, **MKT** is a vector that contains market potential indicators for i that are related to each Type j UL in the initial period (2000), while **ΔMKT** indicates changes in those variables between 2000 and 2010. σ_s controls for fixed effects for each of the 32 Mexican states (i.e., for characteristics such as climate, distance to the border with the USA, or landscape, which are unique to each state and do not vary with time), while $\in$ is the residual term. The use of the lagged levels of the dependent and independent variables attenuates the issue of endogeneity (see discussion in Partridge et al. (2008)).

A negative effect of distance is expected, because the influence of agglomeration, industry mix and congestion that characterizes urban growth is mediated by distance (Partridge et al. 2008). Regarding the expected signs for income and income growth, following Ganning et al. (2013), although the New Economic Geography (NEG) indicates that higher urban incomes (i.e., larger market potential) draw people to the city, higher urban incomes could also increase the purchase of rural goods, rural properties and tourism, potentially resulting in rural growth. The signs of δ and θ therefore are not predetermined and are treated empirically.

We estimate two models:

- Model 1 follows Ganning et al. (2013) and takes into account the joint influence of multiple UL on a given RL by generating a synthetic UL for each RL. Characteristics of these synthetic UL are defined by the average of the characteristics of those UL that are within a given travel time from each one of the RL considered in the data. Attributes for those UL that are within the travel band are weighted by the inverse distance to the RL considered, using row-standardized weights. The travel band was defined as the mean travel time from RL to UL plus one standard deviation, which turned out to be 205 min. To construct the synthetic UL, we considered the two nearest UL of each type (Type1 to Type6) within the 205-min radius of travel time from each RL. Each synthetic UL therefore could consist of the weighted sum of up to 13 localities: two for each of the Type1 to Type6 UL within the 205-min travel band, plus the single Type7 UL in the country (the Mexico City Metropolitan Area).The advantage of this model is its flexibility to take into account market shifts within a given region.
- Model 2 provides further evidence for the joint influence of multiple UL on each RL, by using distances from a given RL *to each* of the closest cities of the seven UL types defined above.

The specifications of models 1 and 2 are as follows:

2.1. Model 1

$$\begin{aligned}\Delta\%Y_{2010y2000,is} &= \beta_0 + \beta_1 distCMA\_S + \beta_{12} distCMA\_SSquared \\ &+ \delta_2 T\_S_2 + \beta_2 distMAT\_S_2 + \delta_3 T\_S_3 + \beta_3 distMAT\_S_3 + \delta_4 T\_S_4 \\ &+ \beta_4 distMAT\_S_4 + \delta_5 T\_S_5 + \beta_5 distMAT\_S5 + \delta_6 T\_S6 \\ &+ \beta_6 distMAT\_S6 + \beta_7 popCMA\_S_{2000} + \beta_8 YpcCMA\_S_{2000} \\ &+ \beta_9 \Delta\%popCMA\_S_{2010-2000} + \beta_{10} \Delta\%YpcCMA\_S_{2010-2000} \\ &+ Y_{2000,i} + StateFixedEffects + \varepsilon_{ist}\end{aligned}$$

where:

- $\Delta\%Y_{2010-2000,is}$ is the percentage change in population between 2000 and 2010 for an RA i, in state s. We also estimate housing quality, housing services and access to health services, where Y is measured as coverage (% of households with access to quality housing materials, housing services, and health services). The dependent variable is measured as the change in coverage between 2000 and 2010. When average schooling is used, the dependent variable measures change in average schooling between 2000 and 2010.
- $distCMA\_S_{2000}$ indicates travel distance in minutes to the nearest synthetic UL of any size. The model also includes this distance squared.
- T_S_k is a dummy variable that indicates that the nearest synthetic UL is of size k, where k.Sizes are: T_1, pop. 15,000 to 49,999; T_2, pop. 50,000 to 249,999; T_3, pop. 250,000 to 349,999; T_4, pop. 350,000 to 499,999; T_5, pop. 500,000 to less than 1 million; T_6, pop 1 million to less than 5 million; and T_7, pop. 5 million and higher.
- $popCMA\_S_{2000}$ is the total population by 2000 in the nearest synthetic UL.
- $popCMA\_S_{k2000}$ is the total population by 2000 in the nearest synthetic UL of size k.
- Ypc_S_{2000} is the per-capita income in the nearest synthetic UL.
- $Ypc\_S\,T_{k2000}$ is the per-capita income in the nearest synthetic UL of size k.

2.2. Model 2

$$\begin{aligned}\Delta\%Y_{i2010-2000} &= \beta_0 + \beta_1 distCMAT_1 + \beta_{12} distCMAT_1 squared \\ &+ \beta_2 distCMAT_2 + \beta_{22} distCMAT_2 squared \\ &+ \beta_3 distCMAT_3 + \beta_{32} distCMAT_3 squared \\ &+ \beta_4 distCMAT_4 + \beta_{42} distCMAT_4 squared \\ &+ \beta_5 distCMAT_5 + \beta_{52} distCMAT_5 squared \\ &+ \beta_6 distCMAT_6 + \beta_{62} distCMAT_6 squared \\ &+ \beta_7 distCMAT_7 + \beta_{72} distCMAT_7 squared \\ &+ \beta_{81} popT_{1_{2000}} + \beta_{82} popT_{2_{2000}} + \beta_{83} popT_{3_{2000}} \\ &+ \beta_{84} popT_{4_{2000}} + \beta_{85} popT_{5_{2000}} + \beta_{86} popT_{6_{2000}} + \beta_{87} popT_{7_{2000}} \\ &+ \beta_{91} YpcT_{1_{2000}} + \beta_{92} YpcT_{2_{2000}} + \beta_{93} YpcT_{3_{2000}} + \beta_{94} YpcT_{4_{2000}} \\ &+ \beta_{95} YpcT_{5_{2000}} + \beta_{96} YpcT_{6_{2000}} + \beta_{97} YpcT_{7_{2000}} + \beta_{101} \Delta\%popT_{1_{2010-2000}} \\ &+ \beta_{102} \Delta\%popT_{2_{2010-2000}} + \beta_{103} \Delta\%popT_{3_{2010-2000}} + \beta_{104} \Delta\%popT_{4_{2010-2000}} \\ &+ \beta_{105} \Delta\%popT_{5_{2010-2000}} + \beta_{106} \Delta\%popT_{6_{2010-2000}} + \beta_{107} \Delta\%popT_{7_{2010-2000}} \\ &+ \beta_{111} \Delta\%YpcT_{1_{2010-2000}} + \beta_{112} \Delta\%YpcT_{2_{2010-2000}} + \beta_{113} \Delta\%YpcT_{3_{2010-2000}} \\ &+ \beta_{114} \Delta\%YpcT_{4_{2010-2000}} + \beta_{115} \Delta\%YpcT_{5_{2010-2000}} \\ &+ \beta_{116} \Delta\%YpcT_{6_{2010-2000}} + \beta_{117} \Delta\%YpcT_{7_{2010-2000}} + \text{StateFixedEffects} + \varepsilon_{ist}\end{aligned}$$

where (we indicate here only those variables that were not defined in the previous models)

- $distCMAT_{k2000}$ indicates travel time distance in minutes to the nearest UL *of size k*.
- $popCMAT_{k2000}$ indicates total population in the year 2000 in the nearest UL of size k.
- $YpcT_{k2000}$ indicates per-capita income in the year 2000 in the nearest UL of size k (proxied by per-capita income in the municipality to which the UL belongs (see endnote 23).

3. Results

3.1. Spatial distribution of rural, rural–urban and urban population and places

Table 1 shows the number of localities and population for rural and urban places. Of 28.2 million individuals living in RL, 11.2 million (about 10% of the total population of Mexico in 2010) lived

[4] In fact, all of these variables are used to compute the official measurement of multidimensional poverty in Mexico.

Table 1
Distribution of rural and urban populations and localities.

Population size (a)	Hinterland within 60 min (*)		Hinterland within 90 min (*)		Urban localities (**)		Total	
	Total population within 60 min of an urban location indicated in (a)	Localities (number) (b)	Total population in less than 90 min of an urban location indicated in (a)	Localities (number) (d)	Population (e)	Localities (number) (f)	Population (a) + (e)	Localities (number) (b) + (f)
Remote								
Less than 15,000	11,232,002	20,439	7,107,504	13,637			11,232,002	20,439
Urban localities								
Between 15,000 & 50,000	6,706,915	9,480	6,149,938	9,852	6,626,045	332	13,332,960	9,812
Between 50,000 & 250,000	5,034,247	6,463	5,388,274	7,793	8,952,418	1,096	13,986,665	7,559
Between 250,000 & 350,000	851,493	760	1,190,986	1,161	3,586,273	387	4,437,766	1,147
Between 350,000 & 500,000	1,008,457	1,038	1,468,784	1,690	4,135,214	803	5,143,671	1,841
Between 500,000 & 1 million	2,276,438	2,427	4,282,314	4,850	16,318,771	2,762	18,595,209	5,189
Between 1 & 5 million	1,163,074	917	2,572,242	2,475	21,084,971	2,165	22,248,045	3,082
More than 5 million	–		112,584	66	20,083,511	961	20,083,511	961
Total	**28,272,626**	**41,524**	**28,272.,26**	**41,524**	**80,787,203**	**8,506**	**109,059,829**	**50,030**

(*) For localities of more than 100 inhabitants. Total population in Mexico in 2010 was 112,336,538. Below the-100 person limit, there are 3,276,709 inhabitants (2.9% of total population), who are not considered in this analysis
(**) Following the Urban National System classifications, an urban locality could be a single city (e.g., La Paz, population 215,178), the sum of conurbated cities (e.g., El Sauzal, population 8832, conurbated with Ensenada, population 279,765, which together total 288,597), or metropolitan areas comprising two or more municipalities (e.g., Mexico City Metropolitan Area, which includes 76 municipalities with a total population of 20,083,511).
Source: Own estimates based on Ministry of Communications and Transport and 2010 Population Census (INEGI).

more than 60 min from any UL (i.e., from a city of at least 15,000 inhabitants). The remaining 17 million rural residents lived near UL of different sizes. Most lived near Type1 (population between 15,000 and 49,999) or Type2 (between 50,000 and 249,999) UL. Regarding the number of localities, the table shows that slightly more than 20,000 RL (i.e., localities with population between 100 and 15,000) are distant from UL of any size, while a similar number are within 60 min of a UL.[5]

Average travel times from rural localities to each of the different types of urban localities are presented in Table 2.[6] The upper part of the table shows that, on average, RL are 114 min from a city of at least 15,000 inhabitants, whereas to reach a mid-size urban locality of 350,000 to 499,999 inhabitants, the average rural dweller must travel 433 min. For people living in remote RL, these travel times are 180 and 525 min, respectively. The lower part of Table 2 shows the average travel time for each hinterland-core classification. For example, a rural inhabitant living within 60 min of a Type1 urban locality travels an average of 34 min to reach the closest urban center, 177 min to reach the higher tier Type2 urban center, and 431 min to reach a UL of 250,000 to 349,999 inhabitants. The Mexico City Metropolitan Area includes 76 municipalities with no RL within 60 min of their geographical centers.[7]

Although it is useful to describe some features of the spatial distribution of the population, it is difficult to argue that a mechanical classification in hinterland-core categories based only on travel times has an economic meaning. A better approach would be to use a finer classification that takes into account actual flows of labor, services and goods between a given rural area and *many* urban localities of different sizes, each at a different distance. An individual from rural locality X may travel to the closest city, which happens to have a population of 15,001, to repair a truck, but may travel to the larger (and more distant) city of 1 million people to buy a new vehicle. This is why, in the econometric section of this paper, Model 1 (our preferred model) uses the effective travel distances from each rural area "***i***" to all urban centers of different sizes (i.e., without considering 60- or 90-min thresholds). Perhaps more importantly, a related problem stems from the fact that our analysis takes single rural localities as the unit of analysis, rather than sets of urban and rural localities that could be identified as functional territories or regions. Very few individuals conduct their social and economic life within the boundaries of a single locality, particularly if they reside in a place that is not a large or very large urban center. The consequences of using multi-location territories rather than single rural locations will be explored in future research.

Map 1 highlights these issues by mapping in light gray those rural localities within 90 min of one urban areas and in dark gray those within 90 min of two or more urban localities. The point is that while 32% of RL are within 90 min of a single UL, 35% are close to two or more UL. A complementary point is that, on average, each UL has 90 RL within a 90-min radius. This underscores the point made earlier about the need to expand this analysis from interactions among single locations to interactions among sets of many urban and rural places that constitute territories.

[5] For comparison, Table 1 also shows information for hinterlands defined with a cutoff of a 90-min travel distance.

[6] Distances may be considered as physical distances (in kilometers) or travel time (in minutes or hours), which takes into account the friction of different terrain types (World Bank, 2009). In this article, we use the second measurement.

[7] There are other ways of measuring distance (to a core labor market area within a metropolitan center, to its legal boundaries, etc.). All are extremely demanding computationally, so we settled for effective travel time by car to the most populated city within each urban area.

Table 2
Average travel time from urban to rural localities (minutes).

Type of locality	Average travel time to an urban locality of size: Between 15,000 & 49,999	Between 50,000 & 249,999	Between 250,000 & 349,999	Between 350,000 & 500,000	Between 500,000 & less than 1 million	Between 1 million & 5 million	More than 5 million
Any rural locality of population less than 15,000	114	187	431	433	268	550	789
Of which: remote localities of population less than 15,000	180	259	496	525	338	639	935
Rural localities that are closer to urban areas of size (*):							
Between 15,000 & 49,999	**34**	177	431	397	241	508	695
Between 50,000 & 249,999	68	**36**	374	359	202	485	706
Between 250,000 & 349,999	80	134	**42**	350	267	422	856
Between 350,000 & 499,999	52	97	170	**43**	157	211	407
Between 500,000 & less than 1 million	47	112	303	260	**43**	517	683
Between 1 million & 5 million	44	114	336	248	185	**47**	372

(*) Rural localities that are within 60 min of an urban area of size indicated in the first column.
Source: Own estimates based on Ministry of Communications and Transport and 2010 Population Census (INEGI).

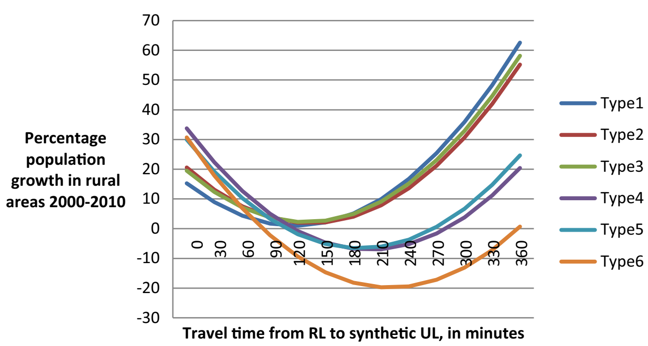


Fig. 1. Access from rural localities to different urban localities in Mexico.

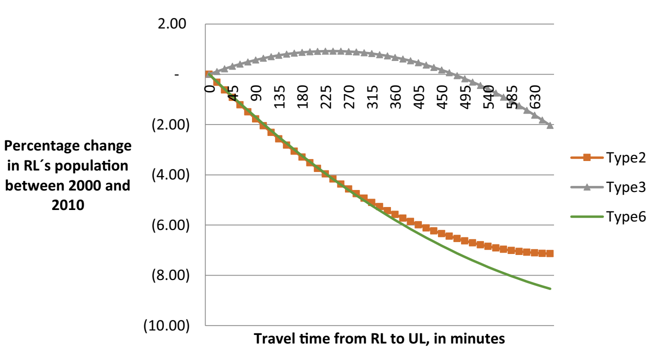


Fig. 2. Changes in population growth in rural locations due to distance from urban locations of different sizes (Model 2).

3.2. Population changes in rural areas

In this section, we assess whether distance to UL is important for population growth in RL, and whether there is a gradient for this effect depending on the population size of the different UL (i.e., whether the effect of smaller UL is observed only in nearby RL, while the effect of larger UL spans a broader geographical area, reaching more distant RL). By incorporating into the models the changes in population and per-capita income in UL, we can also assess how the effect on population growth in RL varies depending on whether the change occurs in a small or a large urban location[8].

When considering the relationship between population changes in RL and their distances to UL of different sizes, our results generally coincide with those found for the USA (Partridge et al., 2008; Ganning et al., 2013): (a) the farther an RL is from a UL, the lower its population growth, and (b) the larger the UL that is close to an RL, the greater the impact of the UL on RL growth. RL population level in 2000 (the initial year) was always negative and statistically significant, showing that population grew faster in smaller localities than in relatively larger ones.

Regarding the impact on RL of changes in UL, and in line with results for the USA, the models show a positive influence of UL population growth on that of RL (perhaps as a response to urban congestion). In contrast with results for the USA, however, our results show in general a negative, but always quantitatively small, influence of UL per-capita income growth on RL population growth, suggesting that market potential in UL absorbs resources away from RL. Because of their small to very small magnitude, those impacts are of low economic significance and we do not provide a discussion of what could be driving them.

Although the main results of changes in UL are similar in the two models, some differences merit discussion. We start by presenting results from Model 1, which considers synthetic UL, and then results from Model 2, which allows coefficients to identify simultaneous effects from different UL without imposing travel time restrictions.[9]

3.2.1. Results from nearest synthetic city model (Model 1)

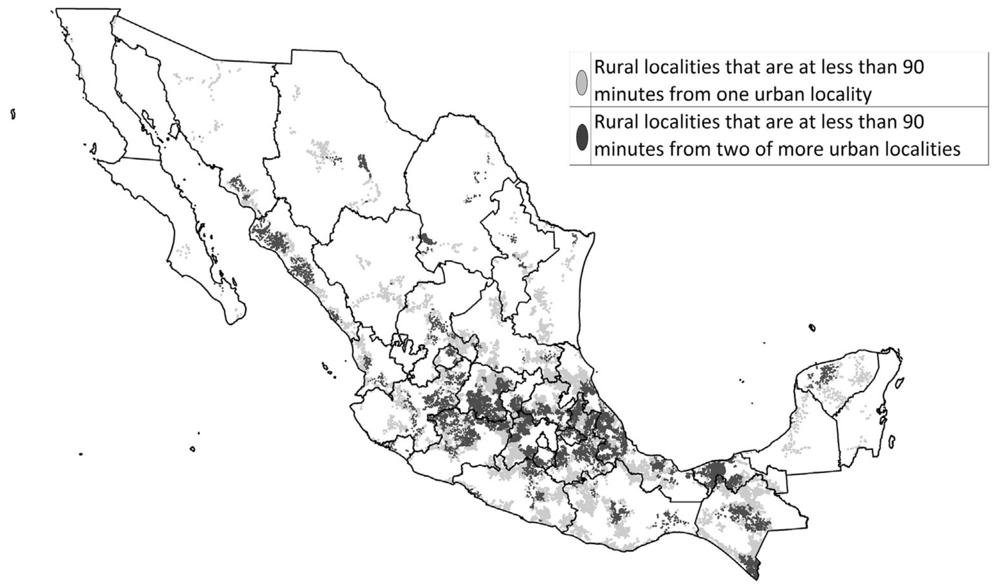
Table 3 shows that the farther the RL is from a synthetic UL, the lower its population growth between 2000 and 2010. This is known as the urban distance discount (pure distance effect) and is calculated by taking into account the distance and distance squared terms. As with findings for the USA (Ganning et al., 2013), urban proximity in Mexico produces spread (positive) effects for RL.[10] For example, being 50 min farther from a synthetic Type1 UL (i.e., population between 15,000 and 49,999) lowers population growth in the RL by 14 percentage points, compared to an RL adjacent to the Type1 UL.[11] This finding is consistent with those of Ganning et al. (2013).

8 The next section models welfare indicators as dependent variables.

9 Appendix 1 contains results of the Central Place type of model, as well as a variation that models incremental distances to different tiers of UL, as in Partridge et al. (2008).

10 We follow the literature in considering that urban agglomeration economies can affect surrounding rural areas in either a positive ("spread") or negative ("backwash") way. See, for example, Partridge et al. (2009).

11 It is important to contrast this result with that of the Central Place model in Table A1 in Appendix 1, which considers only distance to the single nearest city. In that case, being 50 min farther from a Type1 UL reduces population growth by only 1.6 percentage points. This indicates that Central Place models miss the important point that each RL is influenced by multiple UL.



Map. 1.

We have estimated the tipping points where the spread effects diminish to zero and backwash effects begin to dominate. The pattern is a gradient: spread effects of being close to a UL drop to zero at about two hours of travel time from Type1, Type2 or Type3 UL, whereas it takes more than three hours for this effect to disappear when the RL relates to Type4, Type5 and Type6 UL.[12] Again, these results are similar to those of Ganning et al. (2013), who found these tipping points to be between 67 miles (distance to a small city) and 89 miles (distance to a large city).

Model 1 includes dummy variables indicating the urban tier level of the nearest UL (i.e., Type2 to Type6, using Type1 as the base category). Distance to Type4 UL (population 350,000 to 499,999) has the biggest impact on population growth of an RL: when the closest UL is of this type, RL population growth increased by 18.5 percentage points compared to proximity to a Type1 UL (the excluded dummy in the model). Closeness to Type 6 UL (population 1 million to less than 5 million) had the second-highest impact (15.4). This is a significant result, as it shows that small to medium-size cities may have higher positive development effects on surrounding rural areas than larger cities. Fig. 1 shows that the spread effects diminish to zero at about 100 min of travel time from the synthetic UL and that this effect has different rates: higher for larger UL, lower for the smaller ones.

We now discuss the effects of *changes* in key characteristics of the UL on RL population growth. Model 1 captures these impacts by taking into account changes in UL population and per-capita income between 2000 and 2010, as well as their initial levels. Our results show that while population changes in the nearest UL had a positive impact on RL population growth, the effect of changes in UL per-capita income was much smaller and negative (Table 4). Each percentage point of population change in the nearest UL is associated with an increase of 0.48 percentage points in RL population growth. Since the average population growth in UL between 2000 and 2010 was between 16.4% and 24.6%, controlling for distance, UL population growth may have induced between 7.9 and 11.9 percentage points of population growth in RL. This effect could be related to congestion costs, as suggested by Ganning et al. (2013).

We found negative impacts on RL population growth from the initial levels of UL per-capita income, as well as from changes in per-capita income between 2000 and 2010. Following results from Model 1, average RL population growth was 0.046 percentage points lower for each percentage point of per-capita income growth in the nearest synthetic UL (Table 4). Our results are in line with the New Economic Geography hypothesis, which indicates that higher incomes in UL drain RL resources towards urban areas. The economic significance of the coefficients is very small, however, and we therefore argue that rural population growth seems to be driven largely by changes in urban population.[13]

3.2.2. Results from effects of all cities on a single rural location (Model 2)

We now turn to Model 2. We present these results as further evidence that any single RL is influenced by many UL, and not just by the one closest to it, as assumed in models based on Central Place Theory. Our results also suggest that the influence of two or more UL on a single location appears to be simultaneous, rather than hierarchical (i.e., the effects of a larger city do not supersede the effects of any smaller city on any given RL). Table 5 shows the results.

When we control for multiple influences from all UL on a single RL, the impact of distances to UL on RL population growth diminishes considerably and becomes statistically significant only for Type2 (negative), Type3 (positive but small) and Type6 (negative) UL. This is probably due to high colinearity among these variables. To avoid this, Partridge et al. (2008) instrumented a variation of the Central Place Theory model by introducing distances to the nearest UL of any type, as well as incremental distances to UL that are of higher hierarchy. It is our understanding that this procedure, while avoiding the issue of colinearity, greatly reduces the ability to measure the combined influence of UL on a given RL. As indicated

[12] As Table 1 shows, about 7 million people live more than 90 min from even very small cities; these populations are likely to fall beyond the reach of urban spread effects.

[13] Mexico's average population growth was 1.4% per year in the 2000–2010 period. Population growth in rural localities was about 1.9% per year in the same period, while the rate was 2.2% in urban localities with between 15,000 and 100,000 inhabitants. Although there are no data to assess migration at locality levels, these figures are compatible with those of out-migration from the largest cities —which grew at 1.5 % annually — to medium-size cities.

Table 3
Effects of nearest synthetic urban location on rural locations.

	Model 1
Distance to the nearest urban location	−0,24485
	(15.23)***
Distance to the nearest urban location, squared	0,001045
	(14.91)***
Distance to the nearest urban location of Type2	−0,035115
	(4.36)****
Distance to the nearest urban location of Type3	−0,023853
	(1.87)*
Distance to the nearest urban location of Type4	−0,168432
	(10.09)***
Distance to the nearest urban location of Type5	−0,146151
	(8.71)***
Distance to the nearest urban location of Type6	−0,214773
	(10.51)***
Dummy variable for Type2 urban location	5,264107
	(5.97)***
Dummy variable for Type3 urban location	4,171225
	(2.94)***
Dummy variable for Type4 urban location	18,450839
	(9.87)***
Dummy variable for Type5 urban location	14,676584
	(7.41)***
Dummy variable for Type6 urban location	15,405324
	(7.67)***
Population in rural location, year 2000, in thousands	−0,046504
	(2.99)***
% population change in nearest urban location	0,482942
	(21.81)***
% per-capita income change in nearest urban location	−0,046504
	(2.99)***
Population in nearest urban location, year 2000, in thousands	0,000011
	(9.34)***
Per-capita income in nearest urban location, year 2000, in thousands	−0,003901
	(4.31)***
Constant	15,29401
	(6.83)***
State fixed effects	Yes
Adjusted Rsquared	0,10
Number of observations	34,134
F Statistic (47, 37902)	71,54

Note (1) Significance symbols are: *P < 0.10; **P < 0.05; ***P < 0.01.
Note (2): Dependent variable is the percentage change in population in rural localities, 2000–2010.
Source: Own estimates.

above, Ganning et al. (2013) measure this combined influence through synthetic UL; perhaps the main caveat of their approach is that because it is a weighted average, it does not identify the origin of those impacts (i.e., which type of UL generates stronger impacts).

Results from Model 2 corroborate those obtained with Model 1, as most of the coefficients are statistically significant and, at least for UL population growth, their sizes indicate that they are economically important. Model 2 allows further exploration of several issues (Fig. 2). For example, to determine why the effect of Type3 UL was positive when a negative sign was expected, we interacted the distance with dummies for each one of the 12 Type3 UL in Mexico, and found that these results are driven by two localities in the state of Michoacán (Uruapan and Zamora).[14] The economies of these two cities depend largely on the processing of labor-intensive agricultural products (avocado and berries, respectively) from neighboring rural areas, with small and medium-size farmers playing a significant role.

Results in Table 5 show that changes in population in Type1, Type2, Type4 and Type6 UL led to greater population growth in RL. The impact of Type2 (0.30 percentage points) was twice that of Type1 (0.15), while the impact of Type3 (0.43) was almost triple. Interestingly, changes in population in Type3 UL have a negative effect on population growth in RL. We explored this issue further and found that the negative impact comes mainly from two cities: Los Mochis and Colima.[15].

The impact of changes in UL per-capita income was similar to that of Model 1: negative effects on RL population growth, increasing with UL size, and of small economic significance, except for Type4 UL. Further exploration showed that the effect comes mainly from Minatitlán and Orizaba, the only UL in this group that had marked increases in per-capita income.[16]

3.3. Changes in welfare indicators in rural areas

Following a similar econometric strategy as in the previous section, we estimate how changes in welfare indicators in rural localities relate to distances to urban localities, as well as to changes in population and per-capita income in those urban places. We use the following welfare indicators as dependent variables:[17]

1. Changes in the percentage of households with access to quality health-care services (i.e., IMSS, ISSSTE, PEMEX and the Army)[18]
2. Changes in the percentage of households with access to electricity, drinking water and connection to a sewage system
3. Changes in the percentage of school attendance for children between ages 6 and 14
4. Changes in average schooling (years) for those age 15 and older

Table 6 shows descriptive statistics for these variables for all RL. Household access to electricity, water and sewerage more than doubled between 2000 and 2010.[19] Average schooling in RL increased by 1.3 years, reaching 5.6 years in 2010, still well below the national average (9.2 years). Children's school attendance increased slightly from already high levels in 2000, while access to quality health services diminished slightly during the period.

For ease of presentation, Table 7 shows only results from Model 1, which takes into account the combined influence of several UL on each RL using synthetic UL. We ran two sets of regressions for each welfare measurement, one controlling for the UL's starting point of income and population levels (year 2000), as well as changes between 2000 and 2010 (first column for each welfare variable), and another that did not control for these variables.

[14] Michoacán has experienced high levels of violence, particularly since 2006, when the Mexican government launched the "war on drugs." Although we control in the model for state-level fixed effects, the modeling of particular cities within the states certainly adds more information.

[15] We first grouped Type3 UL into four regional groups: i) North: Ciudad Obregón, Ciudad Victoria and Ensenada, 2) Gulf of Mexico: Coatzacoalcos and Córdoba; 3) Pacific: Colima and Los Mochis; 4) Other: Monclova, Tehuacán, Uruapan, Zacatecas and Zamora. We interacted each of these groups with the Change in Population variable to assess whether the negative impact was generalized for all UL of this type and found that results were driven by group 3 (Colima and Los Mochis). Both UL are near the Pacific coast and close to ports (Manzanillo, an important one, and Topolobampo, of lesser importance, respectively). Further analysis shows that population growth in both UL was above average for this group, but no other factors stood out. Further analysis is clearly needed.

[16] We grouped Type4 UL into five groups: i) Center: Cuautla, Irapuato, Tlaxcala-Apizaco; ii) Gulf: Minatitlán, Orizaba; iii) Pacific: Puerto Vallarta, Tepic; iv) Matamoros; and v) Mazatlán. We interacted those groups with the variable Change in Per-Capita Income for Type4. Results were driven by the UL in the Gulf area, with relatively high per-capita income growth during the period considered.

[17] All of these indicators are included in Mexico's official measurement of multidimensional poverty.

[18] IMSS is for private sector employees; ISSSTE, PEMEX and Army cover the public sector.

[19] Cord, Genoni, and Rodríguez-Castelan (2015) documented these trends and were puzzled by the absence of a parallel improvement in income poverty.

Table 4
Induced population changes in rural localities associated with population growth in urban localities.

Urban Location Type	Effects of urban population growth		Effect of urban per-capita income growth	
	Percentage change in population, average for each type, 2000–2010	Population change in rural location (Model 1). Regression coefficient 0.483 (d)	Percentage change in per-capita income, average for each type, 2000–2010	Per-capita income change in rural location (Model 1). Regression coefficient −0.046 (d)
	(a)	(a)*(d)	(a)	(a)*(d)
Type1	16,4	7,9	10,6	−0,5
Type2	22,9	11,1	7,2	−0,3
Type3	20	9,7	5,3	−0,2
Type4	21,7	10,5	−1,7	0,1
Type5	24,6	11,9	0,4	0
Type6	23	11,1	−11,8	0,5

Source: Own, based on Table 3.

Table 5
Effects of all urban locations on single rural locations (*).

Urban Location Type	Travel time to Urban Location	Change in Urban Location population	Change in Urban Location per capita income
Type1	−0,0003	0,152	−0,048
	−0,0700	(9.78)***	(4.76)***
Type2	−0,0211	0,304	−0,054
	(−6.49)***	(12.84)***	(4.71)***
Type3	0,0078	−0,385	−0,068
	(2.70)***	(−4.45)***	−0,910
Type4	0,0042	0,426	0,347
	1,3400	(5.50)***	(10.84)***
Type5	−0,0002	−0,070	−0,088
	−0,0500	(−1.86)*	(2.80)***
Type6	−0,0199	0,233	−0,012
	(6.89)***	(2.13)**	−0,430
Type7	0,0012		
	0,4300		

The dependent variable is the percentage change in population in rural localities between 2000 and 2010.
Standard errors are robust to heteroskedasticity.
(*) t statistic below each coefficient. Statistical significance: ***<1%, **<5%, *<10%.
n = 37,950. Adjusted R2 = .08, F statistic = 48.15.
Included controls for: Urban Location population and per-capita income in 2000, Rural Location population for 2000, state fixed effects, and squared distance terms.

Table 6
Welfare indicators in rural localities. Averages for years 2000 and 2010.

Variable	Average level, year 2000	Change between 2000 and 2010	Average level, year 2010
Households with access to services (percentage)	22,2	23,9	46,1
Average schooling population, age 15 or more (years)	4,3	1,3	5,6
School attendance, children between ages 6 and 14 (percentage)	88,3	6,1	94,4
Households with access to quality health services (percentage)	13,1	0,4	13,5

Source: Own estimates, based on 2000 and 2010 Population Censuses.

Results were qualitatively similar. The following is a description of results from the more complete models.[20]

As Table 7 shows, impacts on the welfare indicators considered were statistically significant and of economic importance only for access to electricity, water and sewerage. The effect was 2.9 percentage points of additional access to services if the closest synthetic urban area is of Type2 (compared to Type 1), with an additional impact of about 9 percentage points for proximity to Type3, Type4, Type5 or Type6 synthetic UL.[21] A marked gradient is observed only for access to electricity, water and sewerage.

Table 7 shows the negative impact on welfare indicators from coefficients that measure distances from RL to a synthetic UL of any size. For access to health services and connection to services (electricity, water and sewerage), there is a clear gradient: Type1 and Type2 have similar impacts (less than 2 percentage points for each 100 min, without considering the quadratic term). Being farther from synthetic Type3 to Type6 UL has a bigger impact (4 to 5 percentage points for each 100 min, without considering the quadratic term).[22] Impacts on school attendance (negative) and average schooling (positive) were very low.

We now turn to changes in RL welfare indicators due to *changes* in UL population and per-capita income. Table 7 shows that while changes in synthetic UL improve RL access to health services, the opposite is true for access to electricity, water and sewerage. One explanation could be that while growth in the nearest UL increased RL households' access to better-quality jobs that included provision of health services, UL outcompeted RL in access to funding for public services such as electricity, water and sewerage. This could be true especially when RL are more distant and therefore require larger investments. Impacts on school attendance and average schooling were much smaller.

4. Discussion

For Mexico, we quantified the effects of urban localities of different sizes on population growth in rural localities. We estimate that when it comes to population growth, stronger rural-urban interactions have positive (spread) effects on rural areas, as increasing rural–urban distance reduces rural population growth. We also find that the size of an urban locality close to a rural locality increases the magnitude of these positive effects on rural population growth, although medium-size cities (i.e., with a population of 350,000 to 499,999 in our analysis for Mexico) tend to have a stronger positive effect than large or very large urban areas. A rural locality that is close to an urban area with a population of 350,000 or more could experience population growth between 10 and 18 percentage points higher over 10 years than that of a more distant rural locality. A compounding effect of 5 additional percentage points could come from population growth

[20] Results from Model 2 were similar and are available from the authors upon request.

[21] Type 1 synthetic UL is the constant in each regression. Dummy coefficients for each UL of the other types were added to this constant to obtain total impact. For example, for household' access to health services (second column of Table 7) the constant is 24.6. Because the dummy coefficient for Type2 is 2.89 and statistically significant, it was added to 24.6 for a total impact of 27.5 from proximity to a Type2 synthetic UL.

[22] The gradients remain after considering the quadratic term.

Table 7
Effects on rural localities of distance to and changes in urban localities.

	Dependent variable is the change between 2000 and 2010 of:							
	Households' access to quality health services, % of households		Households' connection to services, % of households		School attendance, % population between ages 6 and 14		Average schooling, population age 15 or older	
Travel time to the nearest synthetic urban area	−0,021	−0,020	−0,004	−0,006	0,001	0,001	−0,003	−0,003
	(2.23)**	(2.12)**	−0,280	−0,420	−0,530	−0,340	(9.49)***	(9.47)***
Travel time to the nearest synthetic urban area, squared	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	(2.19)**	(1.92)*	−0,480	−0,100	−1,250	−1,070	(6.91)***	(6.84)***
Travel time to the nearest synthetic urban area of Type2	0,006	0,009	−0,020	−0,023	0,004	0,004	0,000	0,000
	−1,090	(1.77)*	(2.57)**	(2.85)***	(2.96)***	(3.19)***	−0,240	−0,080
Travel time to the nearest synthetic urban area of Type3	−0,018	−0,015	−0,050	−0,050	0,002	0,002	0,000	0,000
	(2.74)***	(2.29)**	(4.37)***	(4.41)***	−1,090	−1,270	−1,070	−1,150
Travel time to the nearest synthetic urban area of Type4	−0,021	−0,017	−0,044	−0,045	0,000	0,000	−0,001	−0,001
	(2.53)**	(2.09)**	(2.92)***	(3.02)***	−0,050	−0,110	(2.70)***	(2.75)***
Travel time to the nearest synthetic urban area of Type5	−0,020	−0,008	−0,039	−0,037	0,000	0,001	−0,002	−0,002
	(2.84)***	−1,110	(2.56)**	(2.51)**	−0,130	−0,470	(7.32)***	(7.31)***
Travel time to the nearest synthetic urban area of Type6	−0,031	−0,023	−0,038	−0,044	0,011	0,008	−0,001	−0,001
	(3.80)***	(3.62)***	(1.91)*	(2.74)***	(3.74)***	(3.29)***	(2.98)***	(2.37)**
Dummy variable for Type2 urban area	−1,159	−1,525	2,900	4,122	−0,359	−0,394	0,039	0,041
	(2.16)**	(2.79)***	(3.30)***	(4.79)***	(2.58)***	(2.92)***	(2.13)**	(2.31)**
Dummy variable for Type3 urban area	0,982	0,478	9,059	10,892	−0,412	−0,501	0,014	0,018
	−1,410	−0,690	(7.20)***	(8.97)***	(1.93)*	(2.47)**	−0,500	−0,680
Dummy variable for Type4 urban area	1,837	1,272	8,233	10,429	−0,019	−0,115	0,125	0,137
	(2.15)**	−1,490	(5.08)***	(6.69)***	−0,070	−0,470	(3.51)***	(4.02)***
Dummy variable for Type5 urban area	0,369	−1,126	9,330	11,182	−0,005	−0,254	0,241	0,262
	−0,510	−1,610	(5.66)***	(7.46)***	−0,020	−1,090	(6.73)***	(8.06)***
Dummy variable for Type6 urban area	0,589	−1,673	9,551	11,702	−0,587	−0,872	0,182	0,202
	−0,860	(2.40)**	(5.66)***	(7.39)***	(2.07)**	(3.53)***	(4.57)***	(5.70)***
Population in rural area, year 2000, in thousands	0,003	–	0,004	–	0,000	–	0,000	–
	(5.07)***	–	(4.66)***	–	(1.94)*	–	−1,270	–
% population change in nearest urban area	0,000	–	0,000	–	0,000	–	0,000	–
	−0,490	–	−1,420	–	(2.31)**	–	−1,550	–
% change in per-capita income in nearest urban area	0,086	–	−0,055	–	−0,001	–	0,000	–
	(7.65)***	–	(2.83)***	–	−0,300	–	−0,520	–
Population in nearest synthetic urban area, year 2000, in thousands	0,101	–	−0,073	–	0,004	–	0,001	–
	(9.34)***	–	(5.07)***	–	(1.79)*	–	(2.24)**	–
Per-capita income in nearest synthetic urban area, year 2000, in thousands	−0,125	–	−0,400	–	−0,044	–	0,012	–
	(3.21)***	–	(5.17)***	–	(4.15)***	–	(5.90)***	–
Percentage of households with access to quality health services in 2000	0,772	0,771						
	(135.81)***	(140.25)***						
Percentage of households with access to services in 2000			0,809	0,808				
			(169.47)***	(180.62)***				
School attendance, population between ages 6 and 14 in 2000					0,268	0,268		
					(49.12)***	(49.27)***		
Average years of schooling, population age 15 or older in 2000							0,840	0,844
							(285.38)***	(310.14)***
_cons	−3,696	1,319	24,608	28,323	71,927	72,216	2,224	2,232
	(3.45)***	−1,620	(12.90)***	(18.69)***	(123.63)***	(129.44)***	(46.73)***	(54.88)***
State fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
F statistic	1096,080	1151,170	1303,120	1441,680	124,190	133,930	3330,880	3611,920
Adjusted R-squared	0,430	0,430	0,530	0,530	0,330	0,330	0,850	0,840
# of observations	32,478	32,478	32,263	32,263	32,395	32,395	32,500	32,500

Source: Own estimates.
Standard errors are robust to heteroskedasticity.
Statistical significance: *P < 0.10; **P < 0.05; ***P < 0.01.

rate in those urban areas. Although we found negative (backwash) effects of growth in urban per-capita income, those impacts were quite small. We therefore conclude that population growth in rural areas seems to be driven mainly by distance to urban places and by changes in urban population growth.

When we controlled for multiple influences from all urban localities on a single rural locality, the impact of distances to a city on a rural locality's population growth diminished considerably and was statistically significant in only few scenarios; even then, the effect was small. These results indicate that rural areas interact with multiple cities simultaneously. This does not imply that distance does not matter. On the contrary, as the other model show, it does. Taking into account all interactions of one rural location with urban areas, however, greater distance from the nearest city appears to be offset by the rural location's linkages with other cities of different sizes. Using different data and a very different econometric approach, these results confirm the conclusions in Berdegué, Escobal, et al. (2015).

The policy implications of these findings are many. First, despite the claims of those who continue to maintain that relationships between urban and rural areas in Latin America are fundamentally predatory of the latter by the former, our evidence suggests that, in general, stronger rural-urban linkages should have a positive influence on rural development. Building bridges, rather than walls, between the urban and the rural appears to be the best public policy strategy from the perspective of rural development. Cities are not inimical to the well-being of rural people. In fact, cities are among the most important drivers of contemporary rural development. Rural development policies that ignore urban-rural interactions are missing important opportunities to further their objectives. Our results also suggest that investing in the development of cities should have positive spillover effects on the development of surrounding rural populations.

Secondly, we provide some evidence that these positive effects are larger when rural areas interact with small and medium-size cities (with populations of between 300,000 and 499,999 inhabitants in the case of Mexico). While this is still an open question, because our results are not conclusive, this research strengthens the hypothesis that there are significant differences in the nature of rural-urban interactions, depending on the size of the cities. Anecdotal information suggests, for example, that medium-size cities in Mexico are extremely important for the growth and development of agriculture and as sources of non-farm employment for nearby rural residents. Investing in their development may be an intelligent approach to stimulating the development of surrounding rural areas.

Thirdly, while the measurement of distances between rural and urban places was only an instrumental procedure in this research, we found that a very significant majority of rural people live close or relatively close to a city. The widespread idea that most rural people in Mexico live in isolated or remote places is simply outdated. This has profound implications for the design of rural health care or rural education, for example: should Mexico continue to invest in building secondary clinics and schools in the countryside, or in better transportation services to further facilitate access to urban services for rural people who already live no more than 60 min away?

Finally, given that most rural people live close to a city, the concept of "rural" must be revised in countries like Mexico. These people are rural by residence, but many probably are urban by place of work or study, trade or other dimensions of their social and economic life. The old rural-urban dichotomy must give way to a new concept of a rural-urban gradient, with a very large "rurban" category between the poles.

Nevertheless, urban and rural development policies routinely ignore each other. Fortunately, countries like Colombia, Chile and Guatemala have begun to formulate public policies and strategies that break down the glass wall between urban and rural. These countries emphasize the complementarities between rural and urban and the fact that large proportions of the population live in places, or territories, that are neither purely rural nor purely urban. Rather, they are rural-urban, with villages and small and medium-size cities linked in a dense network of multiple interdependencies (Berdegué and Proctor, 2014). This way of thinking opens a whole new range of development opportunities for both rural areas and cities, as recognized in the New Urban Agenda adopted at the United Nations Habitat III conference in Quito in 2016 (United Nations Conference on Housing and Sustainable Urban Development, 2016).

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Appendix 1. Results from Central Place Theory models.

Model A1

$$\begin{aligned}\Delta\%Y_{2010-2000,is} &= \beta_0 + \beta_1 distCMA + \beta_{12}\text{distCMAsquared} \\ &+ \delta_2 T_2 + \beta_2 distMAT_2 + \delta_3 T_3 + \beta_3 distMAT_3 + \delta_4 T_4 \\ &+ \beta_4 distMAT_4 + \delta_5 T_5 + \beta_5 distMAT_5 + \delta_6 T_6 + \beta_6 distMAT_6 \\ &+ \beta_7 popCMA_{2000} + \beta_8 YpcCMA_{2000} + \beta_9 \Delta\%popCMA_{2010-2000} \\ &+ \beta_{10}\Delta\%YpcCMA_{2010-2000} + Y_{2000,i} + \text{StateFixedEffects} + \varepsilon_{ist}\end{aligned}$$

where:

- $\Delta\%Y_{2010-2000,is}$ is the percentage change in population between 2000 and 2010, for an RA*i*, in state *s*. In this study, we also estimate housing quality, housing services and access to health services, where Y is measured as coverage (% of households with access to quality housing materials, housing services and health services). The dependent variable is measured as the change in coverage between 2000 and 2010. When average schooling is used, the dependent variable measures change in average years of schooling between 2000 and 2010.
- $distCMA_i$ indicates travel distance in minutes from RA_i to the nearest UL *of any size*.
- T_k is a dummy variable that indicates that the UL closest to "i" is of size "k." Sizes are: T_1, pop. 15,000 to 49,999; T_2, pop. 50,000 to 249,999; T_3, pop. 250,000 to 349,999; T_4, pop. 350,000 to 499,999; T_5, pop. 500,000 to less than 1 million; T_6, pop 1 to less than 5 million; and T_7, pop. 5 million and higher.
- $distMAT_k$ indicates travel distance in minutes to UL of size "k," when "k" is the nearest UL.
- $popCMAT_{2000}$ is the population in the year 2000 for the nearest UL.
- $YpcT_{2000}$ is per-capita income in the nearest UL (proxy by the per-capita income of the municipality to which the UL belongs).[23]
- $\Delta\%X$ indicates percentage changes in the variable *X* between 2000 and 2010.
- State fixed effects: The Mexico City Metropolitan Area (the only UL that is Type7) comprises 74 municipalities and, as indicated above, because of its size, no RL is within 60 min of it. We therefore include fixed effects for only 31 of the 32 states (see Tables A1a and A1b).

Model A2

$$\begin{aligned}\Delta\%Y_{2010y2000,is} &= \beta_0 + \beta_1 distCMA_i + \beta_{12}\text{distCMA}_i\text{squared} \\ &+ \beta_2 IncdistMAT_2 + \beta_3 IncdistMAT_3 + \beta_4 IncdistMAT_4 \\ &+ \beta_5 IncdistMAT_5 + \beta_6 IncdistMAT_6 + \beta_7 IncdistMAT_7 \\ &+ \beta_7 popCMA_{2000} + \beta_8 YpcCMA_{2000} + \beta_9 \Delta\%popCMA_{2010-2000} \\ &+ \beta_{10}\Delta\%YpcCMA_{2010-2000} + \gamma_1 Ypc_{2000,i} + \text{StateFixedEffects} + \varepsilon_{ist}\end{aligned}$$

[23] There are no income data for single localities in Mexico. Because many of the UL considered are actually a set of municipalities or are the main cities in a municipality, we proxy UL income here by average income of the municipality(ies) from Small Area Estimates (SAE) at the municipal level, from Enamorado et al. (2014).

Table A1a
Central Place model, effects of distance to the single nearest urban location. The dependent variable is the percentage change in population in Rural Localities.

	Model 1
Distance to the nearest urban location	−0,018933
	(5.27)***
Distance to the nearest urban location, squared	0,000021
	(4.49)***
Distance to the nearest urban location of Type2	0,002785
	−0,65
Distance to the nearest urban location of Type3	−0,013325
	−1,29
Distance to the nearest urban location of Type4	−0,107287
	(8.31)***
Distance to the nearest urban location of Type5	−0,011273
	(1.98)**
Distance to the nearest urban location of Type6	−0,034582
	(4.02)***
Dummy variable for Type2 urban location	1,660864
	(3.10)***
Dummy variable for Type3 urban location	3,511388
	(3.03)***
Dummy variable for Type4 urban location	13,848652
	(9.84)***
Dummy variable for Type5 urban location	2,57713
	(2.40)**
Dummy variable for Type6 urban location	10,425433
	(5.86)***
Population in rural location, year 2000, in thousands	−0,852385
	(10.14)***
% population change in nearest urban location	0,253557
	(17.54)***
% change in per-capita income in nearest urban location	−0,058875
	(5.75)***
Population in nearest urban location, year 2000, in thousands	−0,00119
	−1,21
Per-capita income in nearest urban location, year 2000, in thousands	−0,001109
	(2.59)***
Constant	14,1888
	(7.28)***
State fixed effects	Yes
Adjusted Rsquared	0,07
Number of observations	37,950
F Statistic (47, 37902)	57,35

Note: Significance symbols are: *P < 0.10; **P < 0.05; ***P < 0.01.
Robust standard errors.
Source: Own estimates.

Table A1b
Central Place model, effects of distance to the single nearest urban location. Tipping point where spread effects diminish to zero, backwash effects dominate.

Travel time to the closest urban area of type:	Hours
Type1	7,5
Type2	7,5
Type3	7,5
Type4	50,1
Type5	12,0
Type6	21,2

Source: Own estimates, based on Table A1a.

where (we indicate here only those variables that were not defined in the previous model)

- $IncdistMAT_k$ is the incremental distance to UL of higher population levels. Sizes are: T_1, pop. 15,000 to 49,999; T_2, pop. 50,000 to 249,999; T_3, pop. 250,000 to 349,999; T_4, pop. 350,000 to 499,999; T_5, pop. 500,000 to less than 1 million; T_6, pop 1 to less than 5 million; and T_7, pop. 5 million and higher (see Tables A2a and A2b).

Table A2a
Central Place model, effects of incremental distances to a hierarchy of urban locations. The dependent variable is the percentage change in population in Rural Localities.

Distance to the nearest urban location	−0,021121
	(7.28)***
Distance to the nearest urban location, squared	0,000019
	(4.89)***
Incremental distance to the nearest urban location of Type2	−0,008457
	(3.35)***
Incremental distance to the nearest urban location of Type3	0,00334
	−0,96
Incremental distance to the nearest urban location of Type4	−0,020125
	(4.83)***
Incremental distance to the nearest urban location of Type5	−0,006988
	(4.15)***
Incremental distance to the nearest urban location of Type6	0,000309
	−0,27
Incremental distance to the nearest urban location of Type6	−0,006104
	(5.35)***
Population in rural location, year 2000, in thousands	−0,844023
	(10.04)***
% population change in nearest urban location	0,251112
	(17.63)***
% change in per-capita income in nearest urban location	−0,051128
	(5.23)***
Population in nearest urban location, year 2000, in thousands	0,001209
	(1.98)**
Per-capita income in nearest urban location, year 2000, in thousands	−0,000614
	(1.73)*
State fixed effects	Yes
Adjusted Rsquared	0,06
Number of observations	37,950
F Statistic (47, 37902)	57,35

Note: Significance symbols are: *P < 0.10; **P < 0.05; ***P < 0.01.
Robust standard errors.
Source: Own estimates.

Table A2b
Central Place model, effects of incremental distances to a hierarchy of urban locations Tipping point where spread effects diminish to zero, backwash effects dominates.

Travel time to the closest urban area of type:	Travel time (in hours) to reach the highest negative impact on RL's population growth
Type1	9,3
Type2	13,0
Type3	7,8
Type4	18,1
Type5	12,3
Type6	9,1
Type6	11,9

Source: Own estimates, based on Table A2a.

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