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Productivity, Sustainability, and Economic Growth in Metropolises: Estimates of Long-Time Commuting Effects in Developing Countries

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ABSTRACT: In this study, the long-time commuting patterns of workers in six of the biggest metropolises of the world were observed – New Delhi, Mexico City, São Paulo, Manilla, Nairobi, and Accra – located in very different geographic regions, and all of them coming from the developing world. The main question to be answered was whether there is scope for labor policy changes towards productivity improvements in this area. The findings brought fundamental insights to the debate about big cities' problems to avoid becoming more crowded, congested, and polluted, reducing sustainability, productivity, and economic growth. Simple random samples of workers in the Metropolitan Areas of each city were surveyed electronically, by 'Google-Forms e-survey' during the second half of 2019. The sample proportions were the estimators of the population proportions. Considering specific error margins – below 5 percentage points – for each city, and with a 95 percent point of confidence level, the authors used proportion (p) sample distributions to draw inferences about the population of workers. It was found that long-time commuters are between 12 and 26 percent of the workers who participated in the survey. More than 65 percent of workers in all the cities observed were interested in reducing commuting time. More than half of the workers agreed that reducing commuting time could improve labor productivity, and approximately the same share is aware of the negative effects on quality of life and health. Labor policy changes in these six metropolises have the potential of affecting more than 6.5 million workers.

KEYWORDS: commuting, estimates, metropolis, productivity, sustainability

Introduction

As time goes by and urbanization increases, there is an increase in traffic in any region of the world, and it is more prone to happen in the biggest cities and even more in developing countries metropolises. Commuting time tends to increase in the same direction, as well as environmental pollution since fossil fuels are still the most utilized. Productivity and sustainability are also affected. Long time and long-distance commuters are becoming very common in all the metropolises, especially in developing countries. Quality of life responds to these dynamics, for men and women, rich and poor, young and old, educated, and not educated. However, society does not know how exactly these differences are, in the aggregate and the individual level. The level of awareness of these variables and their relationships may be very low in significant population's proportions, nevertheless, in the biggest cities in the world, a little percentage may count in millions of people. Governments (national, regional, and local) through transport ministries and departments take care of this subject proposing more and better means of transport, demanding more investments, space, and time.

Governors and Mayors of the big cities tend to work 'by urgency,' prioritizing short-term solutions, and postponing long-term investments because they are mostly constrained by budgetary limits. Environmental issues are treated as a secondary, since they are 'important' but not 'an emergency,' like economic problems like unemployment and inflation. Sustainability is a long-term issue, so it can wait!

Employees worried about having jobs and money to take care of their families, prioritize the opportunities for employment based on the time between jobs – unemployment duration. The natural consequence is that the first opportunity of work is accepted, no matter how far it is from home, no matter how long-distance commuting will be needed.

Companies, in the name of the free market, offer job positions looking for the best employees, ignoring these commuting issues, even though the effects tend to spread and affect performance on the job.

In other words, there is a great number of problems that demand new kinds of solutions that are innovative in nature, technologically based, sustainability linked and should go in the direction of turning the biggest cities into more livable. However, to look for the best solutions, the first step is to deep dive into the problems to uncover the hidden factors. The deep dive assist in understanding whether there is a room or not for policy changes in the labor market – specifically in the area of the effect of long-time commuting on productivity, sustainability, quality of life and health of workers.

Although workers feel quality of life is reducing, the effect of environmental pollution is affecting their health, and time spent on commuting is growing out of control. Other factors tend to suppress the ones mentioned and therefore maintain people in this vicious circle. However, is the number of workers facing this problem significant? Are the workers aware of these effects? Is there a possibility of a solution based on labor policy change?

This work intends to collect empirical data in order to provide fresh evidence on the following questions:

1) Is the share of long-time commuters significant in the world´s biggest metropolises?
2) What is the average commuting time in these metropolises?
3) Are people interested in reducing the time spent commuting to work?
4) Do workers agree that reducing commuting time could improve labor productivity?
5) Are workers aware of the long-time commuting effects on their quality of life and health?
6) Is the number of people to be eventually affected by a labor policy change significant?

The answers to these questions are expected to lead to a conclusion which will state if there is room for labor policy changes towards a more productive and sustainable, healthier, and livable world.

Overview of Related Literature

All over the world, big cities have been observed to investigate the causes and effects of long distance and long-time commuting, since it is one of the believed big burdens of big cities. In this body of work, we highlighted some studies for the purpose of reflecting on their experiences.

Historical changes in spatial distribution and economic structure, as well as job and commuting patterns in US metropolitan areas, were investigated, and researchers used data from 1980 to 1990. Results had shown strong growth of suburban cities compared with central cities in each region, increased urbanization economies in suburban cities, the prevalence of suburban agglomeration economies, growing suburban employment centers influencing commuting patterns, and the dominance of suburb-to-suburb commuting. Above all, the authors identified that cities reshape themselves as companies and households chose strategies to lower the costs of transaction labor, services, and all manner of commodities (Lee, Seo, & Webster 2006).

In another research conducted in South Korea, Ma and Banister focused on the jobs-housing imbalance in the Seoul metropolitan area (SMA), aiming to contribute to the debate over sustainable urban development. Their empirical results demonstrated that commuters in the SMA have tried to reduce the imbalance based on time rather than the distance over ten years (1990-2000). The spatial processes of decentralization have been countered by the economic processes of faster travel, with saving as the net result to the commuting time (Ma & Banister 2006).

Another insightful study from the European continent observed changes in the geographical mobility of the populations of post-socialist countries from the 1990s on, focusing demographic and socioeconomic differences between commuters and stayers in the suburbs, as much as commuting time. The mobility of the labor force survey was conducted by the university of

Latvia in Riga. The authors (Krisjane, Berzins, Ivlevs, & Bauls 2012) have concluded that: i) the ones that have suburbanized over the last decade of the 20th century are much likely to commute than stayers, and ii) the probability of commuting is higher for the youngsters and the more affluent ones.

In South America, a team of researchers estimated the influence of the spatial growth pattern of Santiago-Chile, on the environmental impact of commuting.

Findings revealed that (Gainza & Livert 2013):

i) the travel impact increases as the city spreads out, because of the monocentric design of Santiago;

ii) commuting could be reduced by limiting commuters to the area that they live in; and

iii) the use of public transport reduces the impact.

In Shanghai-China, in a study to estimate commuting patterns, the authors assumed commuting as an essential part of urban life, recognizing that long-time commuting has negative effects on individuals and the society, such as stress, productivity loss, and air pollution by the traffic congestions. The study estimated employment locations, and interzonal commuting patterns in central Shanghai, concluding that the worst period is the morning peak hours (Li, Kwan, Wang, & Wang 2018).

Recently, a wider study observed quality of life in urban areas, focusing on development and planning debates. Factors such as environmental health, commuting times, house availability, and others were considered. Authors recognized that the accessibility in multimodal transportation is essential to the functioning of metropolitan areas, and decided to verify its effects on quality of life. They analyzed 148 cities in the US, measuring the percentage of workers who commute using multimodal options. The results had shown a higher quality of life in metropolitan areas with higher levels of multimodal commuting, reinforcing the positive impact of sustainable solutions of transportation policies on quality of life (Talmage & Frederick 2019, 370).

In a study of the relationship between commuting and labor productivity in Australian cities, the authors (Ma & Ye 2019, 25) concluded that:

i) the happy commuters are the more productive; and

ii) the short-distance commuters are more likely to be the happy commuters.

This study has begun as a pilot study in São Paulo-Brazil, to observe the trends in metropolises, and was presented in the IRES-International Conference in that venue, but not published. After the initial estimations, the study was widened into this major research, to observe the long-time commuting patterns of workers in six of the biggest metropolises of the world – New Delhi (India), Mexico City (Mexico), São Paulo (Brazil), Manilla (Philippine), Nairobi (Kenya), and Accra (Ghana) – located in very different geographic regions, and all of them coming from the developing world.

Methods and Procedures

A. Statistical treatment

In this research work, the authors used the sample proportion $\bar{p}$ to make statistical inferences about the population proportion 'p' (Anderson, Sweeney, & Williams 1998). The probability distribution for all possible values of the sample proportion $\bar{p}$ was called the sampling distribution of the sample proportion $\bar{p}$.

The expected interval for p was centered in the result from the sample, which is $\bar{p}$, the mean of all possible values of $\bar{p}$, is expressed as the expected value of $\bar{p}$:

$$E(\bar{p}) = p$$

Where $E(\bar{p})$ = the expected value of the random variable $\bar{p}$

p = the population proportion

The standard deviation of $\bar{p}$ was referred to as the standard error of the proportion. For an infinite population, the standard deviation $\bar{p}$ is expressed by

$$\sigma\bar{p} = \frac{\sqrt{p\times(1-p)}}{n}$$

Where $\sigma\bar{p}$ = the standard deviation of the random variable $\bar{p}$

p = the population proportion

n = sample size

The sampling distribution $\bar{p}$ is approximated by a normal probability distribution whenever the sample size is large (Anderson et al., 1998). The sample size for an interval estimative of a population proportion should be large enough to obtain an estimate of a population proportion at a specified level of precision. The margin of error associated with an estimate of a population proportion is $z_{\alpha/2} \times \sigma\bar{p}$. For a given confidence coefficient $1-\alpha$, $at\ z_{\alpha/2}$ can be determined.

$$n = \frac{(Z_{\alpha/2})^2 \times p(1-p)}{E^2}$$

The margin of error E was calculated by

$$E = z\alpha_{/2} \times \sqrt{\frac{p\times(1-p)}{n}}$$

They were specifying the margin of error as 'below 5%' the confidence level and its correspondence value of $z_{\alpha/2}$ required a planning value for the population proportion p. In this work, the authors based the value for $p \times (1-p)$ in a pilot study, using p = (0.30*0.70) = 0.21 with a confidence level of 95%, so the margin of error was considered for each city sample (n).

Jarque-Bera tests were conducted to check for normal probability distributions.

B. Data Gathering

A questionnaire with 12 questions was administered to workers employed in companies in each metropolis, without discriminating for gender, age, social class, or race. The only attributes demanded to participate were 'to live and work in any of the cities or areas that compose the metropolitan region surveyed.'

The questionnaire was distributed by workers of each city and region, in each country. The workers to distribute the questionnaires were hired by the authors through the 'Upwork virtual workers' (https://www.upwork.com/) and paid by a questionnaire answered. Some workers offered themselves voluntarily to spread the questionnaires in Accra, São Paulo, and Nairobi.

Calculations were done on Excel-Miner stats – 2016, E-views 11 - 2018 version, with samples randomly collected, using Google-forms survey. Jarque-Bera tests were conducted to check for the approximation to the normal probability distribution.

C. Criteria

In a pilot study conducted in São Paulo (Brazil), the commuting time pattern was (Table 1):

Table 1. Commuting Time Pattern in São Paulo-Brazil

Commuting time	Hours
Mean	1,6
Median	1,5
Mode	1

Source: A pilot study conducted in São Paulo

Based on this pattern, the authors assumed that long-time commuting – for the purposes of this work – is the commuting time spent three times the mode or more, so 3 hours or more.

The criteria to choose the megalopolises was i) to have six in total, ii) all of them from developing countries, iii) all of them below US$20,000 per capita, and iv) all coming from the list

of the 150 biggest metropolises in the world, issued by http://www.citymayors.com/ statistics/urban_2020_1.html and v) representing very different geographical regions in the world. The locals surveyed were (table 2), and the population of workers directly affected (table 3):

Table 2. Metropolises from the Developing World (Between the Biggest 150)

Country	Metropolises	World Population Rank Position	Population (2020)	Share of Population Employed	Total Labor Force
India	New Delhi	3	25,830,000	40.2%	10,373,716
Mexico	Mexico City	5	21,810,000	43.5%	9,489,406
Brazil	São Paulo	6	21,570,000	49.4%	10,666,250
Philipines	Manila	14	13,400,000	37.1%	4,968,695
Kenya	Nairobi	73	5,020,000	49.5%	2,483,675
Ghana	Accra	140	3,050,000	40.0%	1,221,005

Source: on http://www.citymayors.com/statistics/urban_2020_1.html

Table 3. Population Directly Affected in Each City

Metropolis	Unemployment Rate (3Q-2019)	Estimated Employed Labor Force	Simple Random Sample	Error Margin (with 95% of C. Level)
New Delhi	8.5%	9,491,951	505	4.0%
Mexico City	3.5%	9,157,277	499	4.0%
São Paulo	11.2%	9,471,630	405	4.5%
Manila	4.5%	4,745,104	570	3.8%
Nairobi	9.3%	2,252,693	543	3.9%
Accra	6.7%	1,139,197	317	5.0%

Source: https://www.worldometers.info

Results and Discussions

The share of long-time commuters showed to be significant in the world´s biggest metropolises, converging to a range from 12% to 26%, as can be seen in table 4:

Table 4. Share of Long-Time Commuters in Each City

Metropolis	Long-time commuters (p)	Error Margin (with 95% of C. Level)	95% C.L. Inferior Limit for p	95% C.L. Superior Limit for p	Number of workers Potentially Affected
N Delhi	14.5%	3.8%	10.7%	18.3%	1,504,189
Mexico City	17.8%	4.0%	13.8%	21.8%	1,689,114
São Paulo	12.1%	4.0%	8.1%	16.1%	1,290,616
Manila	25.0%	4.5%	20.5%	29.5%	1,242,174
Nairobi	23.2%	3.9%	19.3%	27.1%	576,213
Accra	25.9%	5.0%	20.9%	30.9%	316,240
				Total =	6,618,546

Source: Authors calculations

The average commuting-time in these metropolises were considered high, showed to be significant in all the cities, and also showed to converge, as shown in table 5:

Table 5. Average Commuting-Time in the Metropolises (hours)

	Mexico City	São Paulo	Manila	N Delhi	Nairobi	Accra
Mean	1.8	1.6	1.9	1.8	1.8	2
Median	1.5	1.5	1.5	1.5	1.5	2
Mode	0.5	1	1	1.5	1	0.5
Std Deviation	1.1	0.9	1.2	1	1.2	1.2

Source: Authors calculations

Findings showed that many more people than the long-time commuters (below 26%) are interested in reducing the time spent commuting to work. There is a potential to affect 6.6 million long-time commuting workers, but the share interested in avoiding commuting is higher, with the potential to affect almost 30 million workers, as seen in table 6:

Table 6. Share of Workers Willing to Changes to Avoid Commuting

Metropolis	Share of Workers (p)	Error Margin (with 95% of C. Level)	95% C.L. Inferior Limit for p	95% C.L. Superior Limit for p	Number of workers Potentially Affected
N Delhi	64.8%	3.8%	61.0%	68.6%	6,722,168
Mexico City	79.8%	4.0%	75.8%	83.8%	7,572,546
São Paulo	82.0%	4.0%	78.0%	86.0%	8,746,325
Manila	78.6%	4.5%	74.1%	83.1%	3,905,395
Nairobi	77.2%	3.9%	73.3%	81.1%	1,917,397
Accra	74.1%	5.0%	69.1%	79.1%	904,765
				Total =	29,768,596

Source: Authors calculations

A significant share of the workers which agreed that reducing commuting-time could improve labor productivity (table 7).

Table 7. Share of Workers Which Agree with Effects on Labor Productivity

Metropolises	Share of Workers (p)	Error Margin (with 95% of C. Level)	95% C.L. Inferior Limit for p	95% C.L. Superior Limit for p	Number of workers Potentially Affected
N Delhi	55.7%	3.8%	51.9%	59.5%	5,778,160
Mexico City	72.3%	4.0%	68.3%	76.3%	6,860,841
São Paulo	79.5%	4.0%	75.5%	83.5%	8,479,669
Manila	53.7%	4.5%	49.2%	58.2%	2,668,189
Nairobi	68.9%	3.9%	65.0%	72.8%	1,711,252
Accra	68.5%	5.0%	63.5%	73.5%	836,389
				Total =	26,334,500

Source: Authors calculations

The share of workers aware of the long-time commuting effects on their quality of life and health is also shown to be much higher than the long-time commuting share, as seen in table 8.

Table 8. Awareness of Long-Time Commuting effects on Quality of Life and Health

Metropolis	Share of Workers (p)	Error Margin (with 95% of C. Level)	95% C.L. Inferior Limit for p	95% C.L. Superior Limit for p	Number of workers Potentially Affected
N Delhi	55,6%	3,8%	51,8%	59,4%	5.767.786
Mexico City	87,9%	4,0%	83,9%	91,9%	8.341.188
São Paulo	73,2%	4,0%	69,2%	77,2%	7.807.695
Manila	62,2%	4,5%	57,7%	66,7%	3.090.528
Nairobi	57,5%	3,9%	53,6%	61,4%	1.428.113
Accra	68,8%	5,0%	63,8%	73,8%	840.052
				Total =	27.275.363

Source: Authors calculations

Conclusions

The authors found convergence in commuting patterns in metropolises of developing countries, and in the worker's behaviors and interests concerning long-time commuting. The authors concluded that there is room for labor policy changes towards avoiding commuting, and the positive effects on the quality of life and health of the workers may be significant. Moreover, the number of workers potentially affected showed to be astonishing, with possibly high gains in productivity, sustainability, and livability in many developing country cities in the world.

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