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Drought in the city: The economic impact of water scarcity in Latin American metropolitan areas

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ABSTRACT

While the harmful impact of droughts is well-documented in rural areas, how droughts affect cities' economies remains an open question. Using monthly labour force surveys from 78 cities in Latin America, we demonstrate that large sustained dry events decrease the probability of being employed, hourly wages, hours worked, and labour incomes. Informal workers are impacted the most. We highlight that the impact of droughts is larger than the impact of wet events, like those that cause floods. Health and power outages are two pathways explaining our results. Climate change will increase the occurrence of droughts, making our findings particularly relevant.

> You take delight not in a city's seven or seventy wonders but in the answer it gives to a question of yours.
>
> —Italo Calvino, Invisible Cities

1. Introduction

Urban growth is a thirsty business. The increase in urban inhabitants from 54 percent in 2014 to an estimated 66 percent by 2050 (UN-ESA, 2014) is projected to increase cities' demand for water by 50 to 70 percent (Lundqvist, Appasamy, & Nelliyat, 2003; McKinsey, 2009). Yet, one fourth of cities around the world are already water stressed and exposed to perennial water shortages (McDonald et al., 2014).[1] With climate and land use changes, even river basins with important reserves of freshwater, such as in São Paulo or Cape Town, have experienced major droughts over the last years, leading to drastic water shortages. To what extent water availability matters for economic activity in urban settings remains largely unknown. We highlight in this paper that droughts can significantly harm the economic activity of large metropolitan areas. Our results even suggest that the magnitude of the impact of droughts is significantly larger than the impact of wet shocks, like those that cause floods.

Our paper focuses on Latin America, the second most urbanised region of the world after North America (82 percent vs 80 percent, UN-ESA 2014). Our research uses monthly microeconomic labour market data from 78 of the largest cities on the continent between 2005 and 2014. We spatially join them with global gridded weather data from 1900 to 2014 using the centroid of each metropolitan area, allowing us to construct exogenous indexes of droughts based on abnormal deviations from long term means of rainfall. In this natural experiment setting, we show that large and sustained dry shocks (droughts) negatively impact economic activity. Our identification strategy consists in comparing labour market outcomes during drought months and near-normal weather months from workers living in the same city during the same year. During droughts, the probability of an active worker to be employed decreases, as well as the number of hours worked, the wages and the labour incomes of informal employed workers. Our results are robust to several specifications and alternative measures of droughts. They also hold when using different datasets (household surveys, administrative data on the universe of formal Brazilian firms, Enterprise Surveys data), all covering different cities and different periods of time.

There are several reasons to expect such a negative impact of droughts on cities' economies. Hydropower still generates more than 50 percent of electricity in Latin America (Al-mulali, Fereidouni, & Lee, 2014). Generally speaking, water is one of the principal inputs to generate electricity, even beyond hydropower.[2]

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[1] McDonald et al. (2011) modeled results show that currently 150 million people live in cities with perennial water shortage, defined as having less than 100 L per person per day of sustainable surface and groundwater flow within their urban extent. By 2050, demographic growth will increase this figure to almost 1 billion people. They predict that climate change will cause water shortage for an additional 100 million urbanites.

[2] The cooling of many coal, nuclear power plants require hundreds to thousands liters of water per megawatt of electricity produced (Meldrum et al., 2013).

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Consequently, water scarcity can lead to electric shutdowns as was recently seen in India or in Brazil.[3] Using Enterprise Surveys for 22 Latin American and Caribbean Countries, we highlight that droughts significantly increase power outages for firms.

The health literature also points out the negative effects of droughts on health conditions as droughts increase the risk of diarrhea, infections and the survival rate of vectors of diseases (Kovats, 2003), notably in developing countries (Lohmann & Lechtenfeld, 2015). Cities' higher population density favours the rapid spread of diseases compared to rural areas, particularly in the absence of adequate sanitation and sewerage for all households (Ashraf, Glaeser, & Ponzetto, 2016). With a panel of hospital admissions data from Brazil, we also find a worsening of health conditions when droughts occur. This deterioration of health can have direct consequences for labour productivity.

There is a consensus among policy makers that cities are vulnerable to floods. Our empirical model allows us to compare directly the impact of droughts with the impact of similar wet shocks, including wet shocks of an intensity that can cause floods. Compared to droughts, we do not find that large wet deviations cause a general decrease in employment. Also, when large repeated dry shocks decrease monthly labour incomes by six and a half percent, similar wet shocks decrease monthly incomes by two to four percent. Consistently with this finding, both the impact of wet shocks on power outages and health outcomes are smaller than the impact of symmetric dry shocks. While floods tend to attract most of the media attention as a result of their more destructive destruction power (Eisensee and Strömberg, 2007), our paper emphasises the importance for cities to protect themselves from droughts as well.

Our results are striking as Latin America has the highest infrastructure density among developing regions, in spite of its own infrastructure gap.[4] In a recent working paper, Ashraf et al. (2017) find that water outages in the city of Lusaka, Zambia, negatively affect health outcomes and reduce the quantity of financial transactions. Arguably, the quantity and quality of infrastructure in Latin America is better than in less developed countries such as Zambia. Yet, our results show that the problem of water in cities is true for middle incomes countries, and not only in low-incomes countries. Our results also show that the negative economic impact of water scarcity is true at a large geographic scale (one region compared to one city).

The remainder of the paper is organised as follows. Section 2 presents the literature. Section 3 describes the data and the empirical strategy. Section 4 presents our results on the impact of shocks and section 5 analyses pathways. Section 6 discusses the findings and concludes.

2. Prior research

An important literature analyses the impact of positive and negative rainfall shocks on agricultural activity. It shows that even shocks of a small magnitude have important consequences on yields (Zaveri, Russ & Damania, 2018). Droughts then translate into increases in poverty and decreases of key development outcomes such as health and education in developing countries (Kazianga & Udry, 2006; Dercon, 2004), with possible long-term consequences (Dinkelman, 2017; Shah & Steinberg, 2017). For example, it has been shown that rainfall variability impacts agricultural wages (Mueller & Quisumbing, 2011), food prices (Hill & Porter, 2017), gender wage gap (Mahajan, 2017), land invasions (Hidalgo, 2010), local tax revenues (Sanoh, 2015), violence towards women (Sekhri & Storeygard, 2014), and has accelerated the spread of HIV (Burke, Gong, & Jones, 2015).

In comparison, the literature on rainfall shocks in urban areas is more limited. At the city level, looking at 1800 cities between 2003 and 2008, Kocornik-Mina et al. (2015) show that large scale floods (i.e. those displacing more than 100,000 people) reduce night-time lights by two to eight percent within cities the year of the flood, but that even hard-hit cities recover within one year. Acevedo (2015) finds similar results on the impact of floods and on the speed of recovery using microeconomic data on labour markets outcomes in the Colombian Caribbean. Chen (2017) additionally find a small effect of floods on internal migration in Bangladesh. For dry shocks, existing research has shown an indirect effect of droughts on cities. Rural-urban migration increases with droughts as in Africa (Henderson, Storeygard, & Deichmann, 2017; Gray & Mueller, 2012) and recently in Syria (Kelley, 2015). Urban centres are then affected by droughts in the long term due to an accelerated sector reallocation. A rich literature shows that droughts increase the probability of conflicts (Miguel, Satyanath, & Sergenti, 2004; Jia, 2014; Couttenier & Soubeyran, 2014). Almer, Laurent-Lucchetti, and Oechslin (2017) show that the relationship is particularly true in areas close from cities. Again, one might then expect consequences of these conflicts on labour market outcomes.

The literature highlighting a direct economic impact of water scarcity on cities is thin. The closest paper from ours is Ashraf et al. (2017). The authors study the impact of water outages in Lusaka, Zambia. They demonstrate that water outages increase the incidence of diseases (diarrhea, upper respiratory infections, typhoid fever and measles), which translate into a reduction of money-banking transactions and into an increase in the time that girls spend at their chores. If our conclusions converge with Ashraf, Glaser, Holland, et al. (2017), the two papers differ in several ways. When Ashraf et al. (2017) test the impact of water outages using data from the main service provider of water, our paper uses rainfall data. Our paper also adds at least three insights to Ashraf et al. (2017)'s findings. First, we show that not only money banking is impacted but labour market more globally. Second, we add a second pathway to explain the results by demonstrating that power outages for firms increase with droughts. Third, while Ashraf et al. (2017) highlight an impact of droughts in a city with poor infrastructures from one of the least advanced economy on the planet, we show convergent results for cities richer in infrastructures from middle income countries. Hence, our findings suggest that a broad range of countries can suffer from droughts. Our paper is also related to Mueller and Osgood (2009). The authors find a negative impact of negative shocks on wages in rural Brazil using survey data between 1992 and 1995. They are however unable to confirm a direct impact of droughts on wages in urban areas, contrary to our findings.

Our paper also relates to the Climate-Economy Literature (Hsiang, 2010; Hsiang, 2016; Carleton & Hsiang, 2016) that has more recently pushed towards the exploration of the role of temperature as a proxy for climate variations (Dell, Jones, & Olken, 2012; Graff Zivin & Neidell, 2014; Burke, Hsiang, & Miguel, 2015). In particular, Graff Zivin & Neidell (2014) use US daily temperature and individual data from the 2003–06 National Time Use Surveys to show that positive temperature shocks lead to substantial changes in labour supply. Those results echo those found at the macroeconomic level where patterns of responses to variation in temperatures are consistent with labour effects (Hsiang, 2010; Deryugina & Hsiang, 2014; Burke et al., 2015).

Finally, our approach is connected to the literature on large natural disasters. This literature finds mixed impacts of shocks on labour market. In Indonesia, Kirchberger (2017) finds labour mar-

[3] See: http://www.wri.org/blog/2015/06/global-tour-7-recent-droughts and http://www.theguardian.com/world/2015/jan/23/brazil-worst-drought-history.

[4] Fay et al. (2017) notes that some 17 percent of Latin Americans have no access to a private, improved sanitation facility and one-fifth of them still practice open defecation. Additionally, only about a third of wastewater is treated.