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Metro Infrastructure and Metropolitan Attractiveness[*]

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Abstract

The aim of this paper is to investigate whether cities can improve their international attractiveness by investing in their public transport infrastructure. For this purpose, we examine the influence of a metro shock on the number of greenfield foreign direct investment (FDI) projects received by a city during the period 2003-2014. We find that cities which have invested in expanding their metro network have attracted, on average, more FDI than comparable cities which have not improved their urban transport infrastructure.

JEL: R12, R42, F23.

Keywords: City attractiveness, Foreign direct investment, Metro, Urban infrastructure.

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1 Introduction

Cities are perceived to be competing on a global scale to attract foreign investors.[1] Policy makers often advocate investment in public infrastructure to improve urban attractiveness. In recent decades, many urban areas have heavily invested in metro systems.[2] This urban rail-based public transport has its own dedicated infrastructure and is characterised by high service frequency and a relatively dense network of train stations. Figure 1 shows the worldwide increase in the total length of metro lines from 1950 to 2015, by metro age. Over this period, numerous metro networks have been extended and new ones have been built. This strong investment in metro systems can be explained by their capacity to reduce traffic congestion, their easier spatial expansion due to their underground nature, and the signal of modernity that they convey. However, metros carry a large price tag. For example, Baum-Snow et al. (2005) provide estimates of the construction cost of railway lines (including metro lines) in 16 U.S. cities between 1970 and 2000: the building costs varied between 100 and 500 millions of US$ per km. Given the large sums involved, it might be expected that policymakers have strong evidence on the positive effects of metro systems. However, this is not the case.

The goal of this paper is to investigate whether investment in public transport infrastructure does indeed contribute to city attractiveness. More specifically, we focus on the impact of investment in metro systems on a city's ability to attract the location of new greenfield foreign direct investment (FDI hereafter) projects. Obviously a city's attractiveness can encompass a large number of other dimensions, such as population growth or local financial and business conditions. Nevertheless, the amount of FDI projects carried out by profit-maximising firms reflects the relative attractiveness of their targets, providing a useful and traceable indicator of city competitiveness (see, e.g., Guimaraes et al. (2004)). In a sense, by focusing on FDI, we look at the tip of the (urban) iceberg. In addition, as we make clear later, FDI is primarily an urban phenomenon. According to our database, over the period 2003-2014, between 68% and 90% of greenfield FDI were located in urban areas. It is therefore of primary interest to look at the determinants of FDI location decisions

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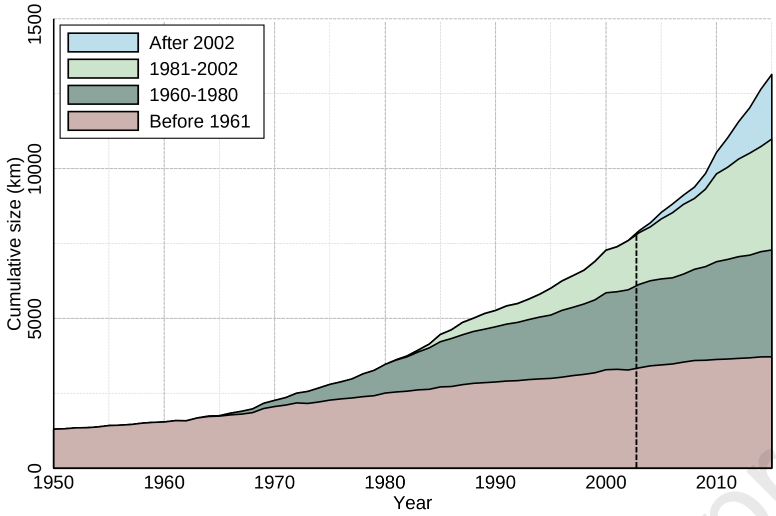
[1] Indirect evidence is the popularity of global rankings such as A.T. Kearney's 'Global Cities' or E.I.U.'s 'Global Liveability Index'.

[2] We use the terms 'city' and 'urban area' interchangeably in the paper. We make very clear our definition of the boundaries of cities in the presentation of the data.

Figure 1: Evolution of the size of metros since 1950

This Figure indicates the cumulative size of metro systems built between 1950 and 2015, by metro age. Data collected by the authors. The dashed line indicates the start of our period of analysis (2003).



at the city level. Regarding metro systems, they are only one of the many dimensions of urban transport infrastructure. However, relative to other infrastructures (e.g. roads or railways) their presence is city-specific and their density tends to vary over time in a clearly identified, and sometimes rapid, manner. Last but not least, building a metro infrastructure is a decision which is likely to be taken by local decision makers; this is less the case for rail or air transport infrastructure which often involves the central government. We focus therefore on the impact of a metro network extension on urban FDI.

The relationship between the presence of a metro network and the attractiveness of a city for foreign investors deserves some discussion. There are, at least, two main channels potentially able to explain a positive connection. First, a metro system can have a signaling effect. Cities endowed with this infrastructure may appear modern and dynamic, with local authorities keen to support their city's economic development. Second, improving the urban transport infrastructure is likely to have positive effects on productivity. Chatman and Noland (2014) disentangle the direct and indirect effect of public transit on productivity in their study of U.S. metropolitan areas. Better transport systems directly decrease commuting costs and indirectly increase agglomeration economies. In a meta-analysis of the literature, Melo et al. (2013) find indeed evidence that transport infrastructure investment induces positive productivity effects which grow over time. However, it ought to be noted that none of the reviewed papers studies the *specific* effect of metro systems.

While our empirical research question is simple, its investigation is challenging. First, it requires matching together city-level attributes, including the presence of a metro, and the location decisions of FDI projects. We have done so for more than 3500 cities over the period 2003-2014. Second, there are various biases which can threaten the causal nature of our estimates. More specifically, treatment and control groups may lack common support and important variables may have been omitted. We address these concerns through pre (before regression adjustment)-processing matching techniques, sensitivity analyses, placebo tests, and an instrumental variables approach.

Our results robustly show that a city experiencing a substantial improvement in its metro density (a 'metro shock') is more attractive to foreign investors. Overall, our estimates suggest that if we compare two similar cities diverging only in their exposure to a metro shock, the treated city is expected to attract about 67% more FDI. Our robustness checks suggest that better urban transport infrastructure reduces congestion and facilitates the modern activities (e.g. business services) requiring intensive face-to-face interactions.

Our paper contributes to two inter-related strands of the economic literature: Urban Economics and FDI. In Urban Economics, most studies have focused on the impact of other transport modes than metro systems: roads,[3] railways,[4] or flight.[5] To the best of our knowledge, there are only two papers addressing directly the effect of metro systems on outcomes unrelated to this study.[6] Furthermore, city attractiveness has hardly been considered with the purpose of attracting foreign investors.[7] A rare exception is Mayer and Trevien (2017) who study the effect of rail transit on FDI. They conclude that the number

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[3] see e.g. Baum-Snow (2007), Duranton and Turner (2011), Duranton and Turner (2012)

[4] see e.g. Baum-Snow and Kahn (2000), Baum-Snow et al. (2005), Mayer and Trevien (2017), Donaldson (2018).

[5] see e.g. Bel and Fageda (2008), Fageda (2017), Tanaka (2019).

[6] Gonzalez-Navarro and Turner (2018) investigate the impact of metro on urban population growth. They find that more extensive metro infrastructure increases urban sprawl but does not affect urban population growth. Gendron-Carrier et al. (2022) study the consequences of opening new metro lines on air quality. They uncover a positive impact.

[7] For instance, Buch et al. (2014) rather study the drivers of cities' attractiveness for workers.

of foreign-owned firms is 20% higher in municipalities connected to the 'RER' network in Paris. We thus expand this literature by investigating the relationship between metro systems and the number of FDI attracted by an urban area.

Our study also adds to the FDI literature by considering cities as the unit of analysis whereas this literature has mostly investigated the relevance of location determinants of FDI at coarser scales, such as at the country level (Blonigen and Piger, 2014). There are a few papers looking at the determinants of location decisions at the regional level in Europe (Crozet et al., 2004; Head and Mayer, 2004; Basile et al., 2008), while Davis and Henderson (2008) and Strauss-Kahn and Vives (2009) examine the location determinants of headquarters in the US metropolitan areas. These studies do not generally examine directly the role of public transport infrastructures.[8] Showing at a worldwide city level that the latter, in particular metro systems, matter for the location decisions of multinational firms is therefore a novel finding.

From a broader perspective, our paper deepens our understanding of what it means, for a city, to be competitive at the international level. This is a key issue given that attracting FDI is often seen as a desirable policy to accelerate economic development (Javorcik, 2015).

The rest of the paper is organised as follows. Section 2 details the construction of our database along with a number of stylised facts. Our empirical strategy is discussed in Section 3. Our results are presented in Section 4. Section 5 provides concluding remarks.

2 Construction of a new city-level database

To be able to carry out the analysis conducted in this paper, we have built an original database of urban areas worldwide. As we make clear below, our database contains a wide range of information stemming from different sources. In addition, we faced several challenges. First, we had to identify urban areas and to rely on satellite pictures to fix their limits. Second, FDI projects had to be geo-located at the city level. Third, no database existed on metro infrastructures. We collected this information by hand.

The construction of the various aspects of this new database is described in detail

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[8] Bel and Fageda (2008) and Strauss-Kahn and Vives (2009) are notable exceptions. These two studies show that the presence of airports influences the decision of headquarter locations.

below. We also provide some descriptive statistics to document the main features of FDI and the presence of metro networks in the world.

2.1 The identification of cities

Scholars working on cities often face the issue of ‘choosing’ the limits of the city when it comes to harmonising and merging data from different sources. First of all, the definition of cities can encompass very different geographic areas in different countries. Second, there is not a common and standard list of city’s identifiers in the world. Finally, in many cases, the urban area of a city can be a much more relevant unit for economic analysis than administrative borders.

In order to overcome that issue, we decided to make use of geo-located data, coming from satellite observations, whose availability and precision are increasing over time. The Lincoln Institute provides a geo-localised database of 3,646 urban areas identified thanks to an evaluation of human-built environment for a grid scale of 500 meters for the entire planet. To do so, the Lincoln Institute uses Modis[9] 500, which is, according to Potere et al. (2009), one of the most accurate databases to represent the urbanised area.

In our empirical analysis, we mainly rely on this definition of urban areas albeit with two modifications. First, given that in some cases the continuity in urbanisation is quite spread over space, some urban areas are actually encompassing two cities. We therefore split some of these areas in two when they correspond to two different cities, as attested by the existence of two distinct transport networks. We end up with $3,729$ urban areas. Second, in our empirical analysis, we consider a FDI project to be located in one of these urban areas as long as it is located within the urban area or within a buffer of 5 kilometres around that urban area.[10] Indeed, some FDI projects might be located at the border of a city in order to benefit from cheaper land while keeping the capacity to benefit from city’s amenities.

We illustrate the meaning of this approach in the online Appendix A.1.

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[9] MODIS stands for Moderate Resolution Imaging Spectroradiometer.

[10] Our results are robust to the use of 1 and 10 km buffers.

2.2 The location of FDI projects at the city-level

Our measure of FDI comes from the *fDiMarkets* database, published by the *Financial Times*, which gathers economic information regarding the worldwide location of 145,000 *FDI* projects over the period 2003-2014.[11] For each project, *fDiMarkets* provides information, among other details, on the date and location of the FDI.[12] These investments are considered as projects because that they tend to be registered in the dataset as soon as they are announced rather than when they actually occur. However, this is not an issue for two reasons. First, if a project happened to be finally cancelled for whatever reason, what matters is the fact the company would have chosen this location in 'normal' times. Second, the providers of this database tried to correct for these 'ghost' projects. Given its numerous advantages, the *fDiMarkets* database has been used, among other papers, by Defever (2006), or Desbordes and Wei (2017) to study location determinants at the country level. Similar data from the Invest in France Agency has also been exploited by Py and Hatem (2010) to study the location decisions of multinational firms in European countries.

To attribute each project to an urban area, we created a table of correspondence between the names of the urban areas in our database and the names of the cities in the *fDiMarkets* database. Table 1 presents the number of projects of FDI we managed to locate by type of FDI (greenfield, extension, co-location) in an urban area, outside our identified cities, and those for which the information was either missing in the database or that we could not locate. In the empirical analysis, we focus on greenfield FDI, which is a cross-border investment in a new physical project, not directly related to previous (i.e. expansion) or other (i.e. co-location) projects. We thus look at the FDI projects which are the most likely to react to contemporaneous changes in city attractiveness. As shown in Table 1, about 68% of the FDI from the *fDiMarkets* database were geolocated in an urban area while about 10% were geolocated outside urban areas. Information on location was missing for about 22% of the projects. In other words, FDI projects are mainly located in urban areas, with between 68% and 90% of greenfield FDI project located in cities. The broad aim of this paper is to understand what makes a foreign investor chooses a city

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[11] `https://www.fdimarkets.com/`.

[12] The database also provides estimations of the amount of each FDI project and the number of job created. We prefer to use the number of FDI because these values have often been estimated by *fDiMarkets*.

rather than another. We therefore dropped those FDI projects that we could not locate or which were located outside one of 'our' urban areas.[13] Our final sample consists in slightly more than 95, 744 FDI projects located in 2,000 urban areas. About 47% of the urban areas in our database did not receive a single FDI over the period 2003-2014.

Table 1: Geolocation of FDI at the city level

This Table indicates the nature and location (within a country) of the FDI projects included in the *fDiMarkets* database over the period 2003-2014.

	Nb of FDI projects (2003-14)	percentage located in urban area	located outside urban area	missing information or not geolocated
Co-location	2,401	65.2%	22.4%	12.4%
Extension	21,846	56.6%	23.4%	20.0%
Greenfield	120,821	67.8%	9.5%	22.7%
TOTAL	145,068	66.1%	11.8%	22.2%

We produce a worldwide map of the distribution of urban FDI along with a table presenting the main investing and receiving countries over the period 2003-2014 in the online appendix A.2. Countries which receive the most FDI are among the largest economies. Figure 2 displays the number of greenfield FDI projects received by the most attractive cities over the period 2003-2014. The cutoff is set at 500 FDI over the period and there are 32 cities in the graph. Among these cities, 9 belong to the European Union, 4 are located in China and India and 2 in the United States. Shangai, Singapore and London are the top three attractive cities with each attracting more than 2500 FDI projects over the period 2003-2014.

Finally, regarding the type of activity, most of the FDI projects in our sample relate to service activities (mainly business services and support services, see Table 2) rather than to manufacturing activities, which represent 20% of greenfield investment only. This is not surprising given that in our analysis we focus on urban FDI and drop from the analysis all the FDI which occur in less urbanised areas. The specialisation of cities in service activities is a phenomenon highlighted by Duranton and Puga (2005).

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[13] It can be reasonably assumed that absence of information on the location of a FDI means that the target location was not easily identifiable, i.e. did not belong to an urban area.

Figure 2: Cities with more than 500 inward greenfield *FDI*, 2003-2014

This Figure indicates the cities which have attracted more than 500 FDI projects over the period 2003-2014. Data come from the *fDiMarkets* database.

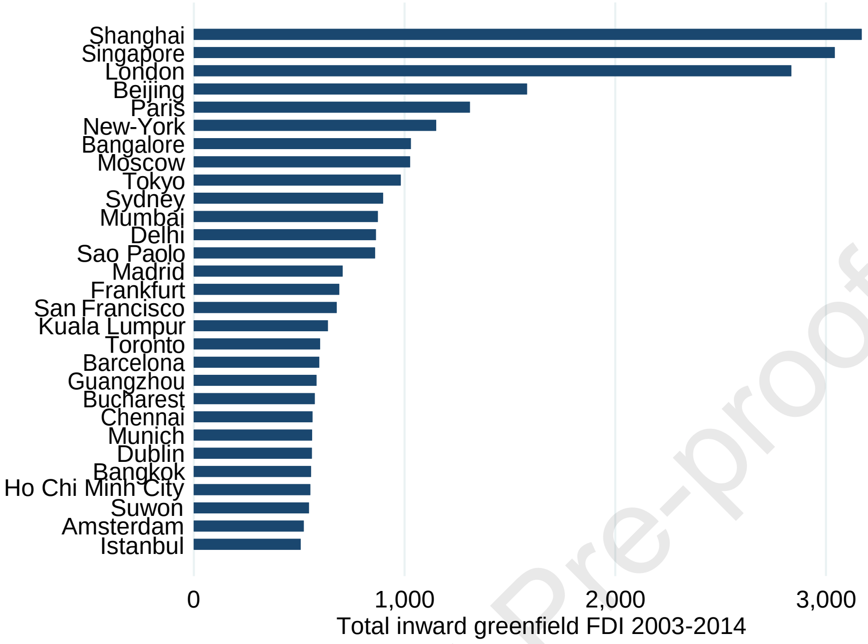

Table 2: Distribution of activities among urban greenfield *FDI*, 2003-2014

This Table decomposes total FDI projects over the period 2003-2014 into their functions. Data and classification come from the *fDiMarkets* database.

Type of activity	Share in greenfield FDI (in %)
Support Services	33.30
Business Services	19.83
Manufacturing Activities	19.79
Infrastructures Services	7.60
Knowledge Services	6.90
Construction	5.03
Headquarter Services	4.38
Energy	3.17

2.3 Metro systems in the world

A comprehensive database gathering information on all metros was not available. We therefore built our own worldwide metro dataset. There are online social communities passionate about metros. The most famous ones are Metrobits[14] and UrbanRail.Net.[15] In addition, a list of metro systems can also be found on Wikipedia. As a starting point, we collected information from these databases. We then used various other sources to complete and cross-check our data. Based on the existing literature, we decided to consider a urban transport system as a metro if it respects the three following characteristics: (i) no sharing of dedicated infrastructure with other transport modes; (ii) high service frequency; (iii) train stations relatively close to one another.[16]

This work enabled us to identify 186 cities with a metro in operation in 2014 and 36 with a metro 'under construction', but not yet in operation. The list of metro cities, a map of the world distribution of metro, and the distribution of the year of creation of metro systems, are provided in the online appendix A.3. Metro systems are much more common in Europe and Asia than in other regions of the world. Table 3 presents summary statistics on metro systems in the world by region. Among the 186 cities with a metro in 2014, most of them (144) either increased or built a new metro infrastructure over the 2003-2014 period. Most cities with a new metro systems are located in Asia (59%) and metro under construction are almost all located in Asia (94%). It also turns out that if Europe had the largest metro network in 2002, it is not the case anymore. Over that period, Asia increased the size of metro systems by almost 150% while Europe and America increased their own metro systems by about 20%.[17] In 2014, the total length of metro infrastructures in the world reached 12,636 km.

Figure 3 presents the 128 cities which experienced a 'metro shock' during the period 2005-2014, ranked by shock size. The metro shock measure is adjusted for the size of the urban area. It is the additional metro length built over the period divided by the city

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[14] http://mic-ro.com/metro/index.html

[15] www.urbanrail.net

[16] We adopted a broad definition, in the sense that light train systems sharing (in part, at least) similar characteristics to metro systems are included in our database. On the other side, we are able to distinguish metros from tramways which share space with private cars.

[17] It is worth stressing that 70% of the new Asian metro infrastructure are located in China.

Table 3: World distribution of cities and metros systems by continent

This Table provides summary statics on the location and expansion of metro networks worldwide. Data have been collected by the authors.

	ALL	ASIA	EUROPE	AMERICA	OTHER
Cities in the sample	3,729	1,973	673	680	403
Cities with a metro in 2014	186	67	73	43	3
New metro cities 2003-14*	49	29	9	10	1
Cities with metro construction/extension 2003-14	144	57	53	32	2
Metro under construction in 2014**	36	34	1	1	0
Metro length 2002 (km)	7,594	2,203	3,221	2,087	84
Metro length 2014 (km)	12,636	5,914	4,035	2,579	108

* Cities without metro in 2002 and with a metro in operation in 2014

** Cities with a new metro line under construction but not yet in operation in 2014

size expressed in square kilometres: $\frac{\Delta\text{metro length (in km)}}{\text{city size (in km}^2)}$. To give an idea of the importance of these shocks, the median value of metro shocks approximately corresponds to the 25^{th} percentile of metro densities in cities having a metro in 2003. Hence, a 'metro shock' is often a substantial change in urban infrastructure. The most dramatic example is the urban area of Nanjing (China) which experienced the largest metro shock. Starting from zero metro system in 2004, 225 kilometres of metro lines were in operation in 2014, for an urban area of about 129 square kilometres. Other Chinese cities and, in Europe, Spanish cities were also characterised by large metro shocks. On the other hand, six large urban areas (more than 1,000 square kilometres) received more than 100 FDI over the period 2005-14 and still had no subway infrastructures in 2014: Johannesburg (South Africa), Jakarta (Indonesia), Melbourne (Australia) Houston, Dallas and San Diego (United States). These few examples illustrate the vast diversity of situations in terms of location and magnitude of the metro shock.

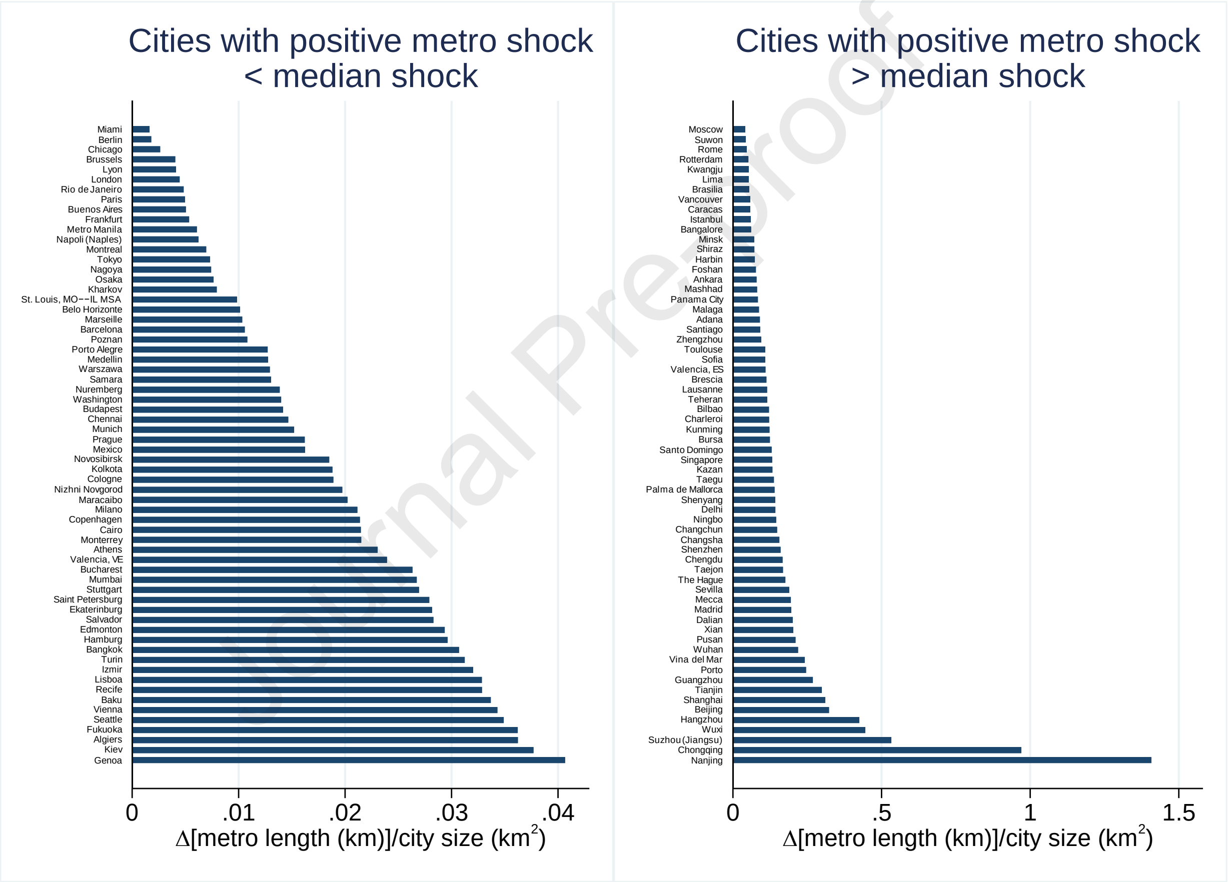
3 Empirical strategy

3.1 Sources of biases

Our goal is to estimate the causal effect of investing in a metro infrastructure (a 'metro shock') on the attractiveness of a city measured by the number of FDI received over a

Figure 3: List of cities with a positive metro shock over the period 2005-2014, by shock size

This Figure provides the list of cities which have experienced an increase in their metro systems. Cities are distinguished according the size of this 'metro shock' ($\frac{\Delta\text{metro length (in km)}}{\text{city size (in km}^2)}$).



given period of time. King and Zeng (2006) show that the difference between the average causal effect of a 'treatment' (here the metro shock) and the observed difference in means can be decomposed into four components: omitted variable bias, post-treatment bias, interpolation bias, and extrapolation bias.

Omitted variable bias covers all forms of endogeneity induced by a correlation between an explanatory variable and the error term and which could be remedied by controlling for additional variables, notably through a control function/instrumental variables (IV) approach. *Post-treatment bias* is when the equation includes control variables which are, at least in part, consequences of the treatment. Researchers usually deal with both issues by including a series of pre-treatment control variables correlated with both the treatment and the dependent variable.

The last two biases are more subtle. The issue with *interpolation bias* is that the right control variables may have been selected but they may adjust imperfectly for raw group differences because the functional form is misspecified (by assuming for example linearity). Lastly, *extrapolation bias* occurs when, in the data, it is not possible to find treated and control units which share the same characteristics. In that case, without overlap, the comparisons are made on the basis of model-dependent forecasts, which may generate poor counterfactuals. Matching techniques have become increasingly popular to adjust unit differences in a non-parametric way and find observations with common support.[18]

In our empirical approach, we adopt five strategies to circumvent these sources of bias. First, the model contains a lagged dependent variable to capture time-invariant unobserved determinants of city-attractiveness. Second, all control variables are measured pre-treatment. Third, we use a correlated random effects (CRE) approach to control for country characteristics. Fourth, we adopt a pre-treatment matching strategy to make the treated and untreated groups more comparable. Fifth, to deal with any potential remaining endogeneity issue, we adopt an IV approach where we interact soil types with past population growth to build relevant and valid instruments. These five strategies (detailed hereunder) give us confidence in the causal interpretation of our results.

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[18] See Morgan and Winship (2015) for a comprehensive overview of matching techniques.

3.2 Empirical approach

Our measure of attractiveness is cumulated FDI flows over the period 2005-2014. While FDI flows are available on a yearly basis, they are quite volatile. This is not surprising given that new (domestic and foreign) investment at the firm-level is discrete and occasional (King and Thomas, 2006). It thus makes more sense to focus on cumulated FDI flows to separate the attractiveness from the noise (of yearly variations).

Our econometric model includes a lagged dependent variable, the initial metro density, and pre-treatment control variables. Intuitively, by controlling for the first two variables, we limit the possibility of an omitted variable bias since they are both a function of the potentially relevant but omitted unobserved factors (Angrist and Pischke, 2009; Beck and Katz, 2011; O´ Neill et al., 2016). Our baseline estimated model is then

$$\begin{aligned} E(FDI0514_{cp}|x) = exp(&\theta FDI0304_{cp} + \gamma Metro2004_{cp} + \tau \Delta Metro_{cp} \\ &+ CV\,init_{cp}\beta) \end{aligned} \tag{1}$$

where $FDI0514$ is the cumulated values of FDI projects received by city c in country p over the period 2005-2014, $FDI0304$ (the lagged dependent variable) is the total number of FDI projects obtained in 2003 and 2004, $Metro2004$ is the density (metro length/km^2) of the metro system in 2004. $\Delta Metro$ is our main variable of interest. We (initially) use various measures of a metro shock: a continuous measure of the increase of metro density (change in metro length between 2005 and 2014/km^2) or dummy variables defined as taking the value of one if the change in metro densities between 2004 and 2014 exceeds zero or, in turn, the values of the first, second or third quartile of strictly positive metro density changes in the sample. $CV\,init_{cp}$ correspond to control variables measured at the city level pre-sample, i.e. circa 2000. Since our dependent variable is a count variable, we estimate a Negative Binomial regression model (NBRM) with quadratic variance function (Winkelmann, 2008; Cameron and Trivedi, 2013).[19] Standard errors are clustered at the

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[19] We could have used a Poisson Regression model but our count data are overdispersed, violating thus the equidispersion property of the Poisson distribution. This overdispersion can be explicitly modeled in a NBRM. Furthermore, in line with the recommendations of Cameron and Trivedi (2013), we adopt an exponential feedback model, in which the lagged dependent variable is in levels and part of the exponential mean function.

country level.

We would like to include country fixed effects to eliminate any omitted variable bias at the country level. There does not exist a true Negative Binomial fixed effects estimator (Allison and Waterman, 2002; Guimaraes, 2008). Following Cameron and Trivedi (2013), we therefore adopt a correlated random effects (CRE) model such that the country fixed effects are considered to be a linear function of the country-averages of the urban area-specific variables ('CRE terms') and an uncorrelated error term. By including these CRE terms in equation (1), we mimic a fixed effects approach since the coefficients on our explanatory variables are solely identified on the basis of within-country deviations.[20]

As previously mentioned, these regression adjustments are unlikely to be sufficient to guarantee that control and treatments groups offer acceptable counterfactuals. We follow the approach suggested by Ho et al. (2007) in using matching to preprocess the data in order so that both groups are very similar to each other *before* we estimate equation (1). This two-step approach (matching and regression approach) is 'double-robust' and allows the use of standard regression methods. To make full use of our data, we adopt Mahalanobis-distance kernel matching. The Mahalanobis distance measures the overall distance between the characteristics of two observations and less weight is given to observations which are distant.[21] We then apply the matching weights generated to estimate a Weighted Negative Binomial regression model (WBNERM) in which a better 'pre-regression' balancing of control and treatment groups is obtained by strongly reducing raw differences in means and variances and therefore increasing the similarities between the distributions of the two groups before regression adjustment.

We use all control variables, including the CRE terms, in the matching procedure. In that way, we ensure that we are matching as much as possible observations similar to each other, both city-wise and country-wise. In a few cases (about 1% of total observations), despite our kernel-matching approach, some observations could not be matched because they were too different ('distant') from other observations. However, as discussed by Ho et al. (2007), the loss of a small number of observations is very unlikely to have a meaningful

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[20] In unreported regressions, we verify that out key results hold when we control for country fixed effects using a consistent fixed effects estimator, such as the Poisson fixed effects estimator (Wooldridge, 1999).

[21] We use the Stata -kmatch- command developed by Jann (2017), with automatic bandwidth selection.

impact on the variance of the coefficient associated with the treatment effect, notably if the control units largely exceed the treated units.

Coming back to the omitted variable bias, it remains possible that we have omitted relevant control variables or that FDI and metro expansions are simultaneously determined. Once we have included as many control variables as we can, including country fixed effects, such a worry may be addressed in two different ways. First, endogeneity can be solved through an instrumental variable estimation. We use interactions between soil types, and past population growth to construct meaningful instruments. Second, some functions of FDI, e.g. modern services, ought to be more sensitive to a metro network than other functions, e.g. manufacturing. Finding such a pattern would sharpen the probability of a causal link between FDI and a metro network.

3.3 Control variables

We control for market size, political power, infrastructure. These characteristics have often been found to determine FDI and can be correlated with the presence of a metro network (Blonigen and Piger, 2014; Nielsen et al., 2017).

The market size is assessed by the use of both, the log of *gross value added per capita* in 2000 and the log of *total population* in 2000. Data come from Kummu et al. (2018). These variables measure market size, market potential and, to a certain extent, city productivity.

We include a dummy variable which takes the value of one if a city is the *administrative capital* of the country.

We also take into account the availability of transport infrastructure connecting the city with the rest of the world and/or facilitating the movement of goods and people between cities: *airport*, *port*, *railways*. The port and airport variables are dummy variables which take the value of one if there is, respectively, a port or an airport of medium or large size within a distance of 50 km. All other variables are expressed in number of km. The length of railways are measured with a buffer of 10 km around the borders of urban areas and normalised by the urban area. Data on airports, roads and railways come from the 1997

Global VMap0 dataset created by the U.S. National Geospatial Agency.[22] Data on ports come the World Port Index.[23]

Lastly, we include *continental dummy* variables for the following continents: Africa, Asia, Europe, North America, Oceania, South America. In that way, we can account for continent-specific determinants.

4 Results

4.1 Naive estimates

We start by presenting 'naive' estimates, which may suffer from various biases, in Table 4. We use the continuous values of our measure of a metro shock. In columns (1) to (4), we add control variables sequentially but omit country fixed effects (proxied by 'CRE terms'). In column (5), we add country fixed effects (CRE). In column (6) we restrict the sample to cities endowed with a metro system in 2014. Overall, we find that improving metro infrastructure is associated with an increase in city's attractiveness. In the rest of the paper, we consider regression (5) as our baseline model specification.

Before adopting a pre-regression matching adjustment, we replicate regression (5) of Table 4, using now the dichotomous measures of metro shocks. The dummy variables are defined as taking the value of one if the change in metro densities between 2005 and 2014 exceeds zero or, in turn, the values of the first, second or third quartile of strictly positive metro density changes in the sample. Results are presented in Table 5. We find that metro shocks need to be relatively substantial (above median) to have a positive influence on FDI.

4.2 Matching estimates - baseline results

In this section, we implement a pre-processing matching approach to reduce interpolation and extrapolation biases. The first step consists of matching treated and untreated observation which requires to define what is a treated observation. Indeed, if the treated group

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[22] `https://gis-lab.info/qa/vmap0-eng.html`

[23] `https://msi.nga.mil/Publications/WPI`

Table 4: The impact of a metro shock on FDI (continuous measure)

The dependent variable is the total number of greenfield FDI received by a city over the period 2005-2014. The independent variable of interest is the metro shock which is defined as $\frac{\Delta\text{metro length (in km)}}{\text{city size (in km}^2)}$ between the years 2005 and 2014. It is equal to zero if there was no metro expansion over the period and it is strictly positive otherwise. In the last column, we restrict the sample to cities endowed with a metro system in 2014.

VARIABLES	(1) NBRM FDI 05-14	(2) NBRM FDI 05-14	(3) NBRM FDI 05-14	(4) NBRM FDI 05-14	(5) NBRM FDI 05-14	(6) Metro cities NBRM FDI 05-14
Δ metro density (cont.) 2005-14	0.584	1.088***	1.872***	1.894***	2.234***	1.109***
	(0.376)	(0.396)	(0.497)	(0.514)	(0.374)	(0.362)
Metro density 2004	0.111	-1.716**	-1.818***	-1.763***	-3.229***	0.505
	(1.196)	(0.708)	(0.680)	(0.672)	(1.183)	(1.150)
FDI 2003-04	0.075***	0.066***	0.047***	0.047***	0.038***	0.004*
	(0.020)	(0.019)	(0.015)	(0.015)	(0.010)	(0.002)
ln(GVApc 2000)	0.437***	0.497***	0.473***	0.472***	0.720***	0.589***
	(0.146)	(0.140)	(0.145)	(0.144)	(0.242)	(0.228)
ln(Population 2000)	0.883***	0.857***	0.737***	0.717***	0.890***	1.226***
	(0.132)	(0.140)	(0.157)	(0.156)	(0.152)	(0.109)
Capital city		1.614***	1.254***	1.228***	0.368	-0.122
		(0.273)	(0.197)	(0.194)	(0.231)	(0.229)
Airport			0.861***	0.867***	0.752***	0.336
			(0.125)	(0.127)	(0.156)	(0.259)
Port			0.360***	0.346***	0.315***	-0.076
			(0.123)	(0.123)	(0.100)	(0.142)
Rail density 2004				-0.119	-0.068	0.051
				(0.092)	(0.074)	(0.281)
Observations	3,516	3,516	3,516	3,516	3,516	176
Cont. dummies	YES	YES	YES	YES	YES	YES
CRE	NO	NO	NO	NO	YES	YES
Pseudo R2	0.143	0.152	0.160	0.161	0.177	0.117
Mean dep. var.	18.80	18.80	18.80	18.80	18.80	18.80

Cluster-robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

NBRM: Negative Binomial Regression Model

Table 5: The impact of a metro shock on FDI (dichotomous measures) shock on FDI

The dependent variable is the total number of greenfield FDI received by a city over the period 2005-2014. The independent variable of interest is a dummy equal to one if the metro density shock is strictly positive (col. 1), above the first quartile (col. 2), above the median (col. 3) or above the third quartile (col. 4) of strictly positive metro density changes in the sample.

VARIABLES	(1) NBRM FDI 05-14	(2) NBRM FDI 05-14	(3) NBRM FDI 05-14	(4) NBRM FDI 05-14
D[Δ metro density > 0]	0.206			
	(0.232)			
D[Δ metro density > first quartile]		0.360		
		(0.274)		
D[Δ metro density > median]			0.562**	
			(0.285)	
D[Δ metro density > third quartile]				0.791***
				(0.295)
FDI 2003-04	0.041***	0.040***	0.039***	0.038***
	(0.010)	(0.010)	(0.010)	(0.011)
Metro density 2004	-3.136*	-3.272**	-3.195**	-2.956**
	(1.705)	(1.629)	(1.549)	(1.346)
ln(GVApc 2000)	0.742***	0.748***	0.726***	0.725***
	(0.250)	(0.251)	(0.249)	(0.250)
ln(Population 2000)	0.883***	0.886***	0.882***	0.888***
	(0.148)	(0.147)	(0.146)	(0.148)
Capital city	0.328	0.323	0.340	0.377*
	(0.247)	(0.244)	(0.235)	(0.222)
Airport	0.754***	0.737***	0.752***	0.759***
	(0.154)	(0.153)	(0.154)	(0.155)
Port	0.300***	0.298***	0.300***	0.309***
	(0.109)	(0.109)	(0.106)	(0.102)
Rail density 2004	-0.056	-0.061	-0.064	-0.061
	(0.073)	(0.074)	(0.074)	(0.074)
Observations	3,516	3,516	3,516	3,516
Cont. dummies	YES	YES	YES	YES
CRE	YES	YES	YES	YES
Pseudo R2	0.174	0.175	0.175	0.175
Mean dep. var.	18.80	18.80	18.80	18.80

Cluster-robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

NBRM: Negative Binomial Regression Model is composed by all cities with a positive metro shock, the two groups may remain significantly different from one another. An alternative which could allow for better matching consists in considering that only cities with a metro system increase above a given threshold (above the median of cities with a strictly positive metro system expansion, for instance) are 'treated'. Since we have no *a priori* reason to select one threshold instead of another, we tested four thresholds: positive metro shock, and metro shocks above the first quartile, the median, and the third quartile of cities with a positive metro shock, respectively. For the second step, we use here a weighted regression to obtain a better balancing between control and treatment groups. The estimated coefficients on metro shock are not very sensitive to the threshold choice, although they suggest that the positive effect on FDI increases with the size of the metro shock.

In the Appendix, we show that matching does indeed substantially improve balancing by strongly reducing raw differences in means and variances and therefore increasing the similarities between the distributions of the two groups. Nevertheless, differences remain, justifying a subsequent regression adjustment. Generally speaking, the quality of the matching increases when we use more restrictive thresholds, at the cost of having a smaller amount of 'treated' cities. From now, we keep two thresholds: all cities with a positive metro shock over the period and above median. All further results will be obtained with the weights used in columns (1) and (3) of Table 6, depending on the chosen threshold.

Overall, the matching adjustment does not alter our initial finding that a substantially larger metro system improves a city's attractiveness. However, it improves our confidence that we are comparing, after both non-parametric and parametric adjustments, like for like cities. We find, on the basis of the estimates of columni (3) of Table 6, that cities experiencing a metro shock received about 67% more FDI than what they could have expected in the absence of this shock. This is a large economic impact. It is interesting to note that stricter metro shock thresholds are associated with larger effects suggesting a real effect of better transport infrastructure, and not simply a signalling effect of other, non-observed, city changes.

Table 6: The impact of a metro shock for matched observations

The dependent variable is the number of greenfield FDI obtained by a city over 2005-2014. All observations are weighted using a pre-regression matching algorithm. The algorithm is applied separately for each column. When observations are not matched, they are excluded (which explains the change in the number of observations across columns). The independent variable of interest is a dummy equal to one if the metro density shock is strictly positive (col. 1), above the first quartile (col. 2), above the median (col. 3) or above the third quartile (col. 4) of strictly positive metro density changes in the sample.

	(1)	(2)	(3)	(4)
	WNBRM	WNBRM	WNBRM	WNBRM
VARIABLES	FDI 05-14	FDI 05-14	FDI 05-14	FDI 05-14
D[Δ metro density > 0]	0.602***			
	(0.185)			
D[Δ metro density > first quartile]		0.543**		
		(0.215)		
D[Δ metro density > median]			0.512**	
			(0.248)	
D[Δ metro density > third quartile]				0.955***
				(0.291)
FDI 2003-04	0.037***	0.031***	0.026***	0.013***
	(0.006)	(0.007)	(0.008)	(0.005)
Metro density 2004	-2.100*	-1.546	-2.369***	-2.057***
	(1.232)	(1.342)	(0.835)	(0.680)
ln(GVApc 2000)	0.758***	0.787***	0.940***	0.775***
	(0.153)	(0.186)	(0.187)	(0.204)
ln(Population 2000)	0.972***	1.055***	1.109***	1.118***
	(0.138)	(0.143)	(0.151)	(0.125)
Capital city	0.072	0.070	0.153	0.420
	(0.196)	(0.220)	(0.209)	(0.343)
Airport	0.060	0.062	-0.028	0.116
	(0.190)	(0.215)	(0.208)	(0.286)
Port	0.031	0.097	0.320*	0.155
	(0.127)	(0.155)	(0.177)	(0.123)
Rail density 2004	0.117	0.127	0.040	0.099
	(0.113)	(0.108)	(0.110)	(0.120)
Observations	3,477	3,480	3,478	3,487
Cont. dummies	YES	YES	YES	YES
CRE	YES	YES	YES	YES
Pseudo R2	0.173	0.169	0.176	0.181
Mean dep. var.	58.89	51.76	51.19	67.06

Cluster-robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$
WNBRM: Weighted Negative Binomial Regression Model.
Weights are obtained from multivariate distance matching (kmatch command in Stata).

4.3 Asserting causality

In the previous section, we have shown that there is a strong partial correlation between FDI and a metro shock. However, this does not mean that this relationship is causal. There are several ways of confirming the validity these estimates.[24]

First, an instrumental variables (IV) approach can deal with general concerns about endogeneity. Broadly speaking, a metro shock must be desired and feasible. Better urban transport infrastructure is more likely to be desired when existing transport networks are congested. Fast population growth naturally contributes to public transport saturation. A metro involves digging tunnels in soils whose composition may facilitate or hinder excavation. Soil types play thus a role in the ability of cities to meet a demand for more public transport by building a metro. Hence our instrumental variables for a metro shock are the interactions of the dominant soil type in each urban area with population growth between the years 1990 and 2000.[25] Intuitively, our instruments capture the fact that the 'natural' conditions for demand and supply for a metro exist. While the individual components of these interaction terms (past population growth and soil types) may themselves be correlated with our dependent variable, we do not expect their interactions to have an effect on FDI besides their indirect, metro shock-induced, effect.[26]

To perform this analysis and obtain IV diagnostics, we use a linear regression model with $IHS(FDI0514)$ as dependent variable.[27] Columns (1) and (3) of Table 7 show that our results are qualitatively unchanged when using this alternative model specification. Columns (2) and (4) display the second-stage regression and the IV diagnostics. The coefficients on metro shocks are positive, statistically significant, but slightly smaller than those from the OLS regressions, suggesting a mild positive endogeneity bias. The instru-

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[24] Note again that we always run weighed regressions from now. To improve comparability, applied weight are those obtained in columns (1) and (3) of Table 6

[25] Soils are classified in 27 categories which are detailed here `http://geonetwork.grid.unep.ch/geonetwork/srv/en/metadata.show?uuid=fb650de3-28d4-4461-92bd-36f5182b0de3`.

[26] As a robustness check, we also included these individual components as control variables. Results are similar and available upon request.

[27] The IHS (inverse hyperbolic sine) transformation behaves similarly to a logarithmic transformation but is defined at 0. As a robustness check, we also tested $ln(FDI0514+1)$ as dependent variable. Results are similar.

ments appear relevant (first-stage F statistic close to 10) and exogenous (p value of the overidentifying restrictions test greater than 0.10).

Table 7: The impact of a metro shock: looking for causality

The dependent variable is the number of greenfield FDI obtained by a city over 2005-2014. All observations are weighted using a pre-regression matching algorithm. The algorithm is applied separately for each column. The independent variable of interest is a dummy equal to one if the metro density shock is strictly positive or above the median of strictly positive metro density changes in the sample. In columns (1) and (2), we adopt an IHS transformation of the dependent variable to deal with zero values and estimate the econometric model by (weighted) OLS (WOLS). In columns (2) and (4), we use a weighted instrumental variables (WIV) approach, using as instruments the interactions of 27 soil types with the 1990-200 population growth. In columns (5) to (8), we examine the impact of metro shocks on the number of greenfield FDI projects in modern services (MOD) or in the manufacturing sector (MAN). Here, we use a weighted Negative Binomial regression model (WNBRM).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	WOLS	WIV	WOLS	WIV	WNBRM	WNBRM	WNBRM	WNBRM
VARIABLES	IHS(FDI 05-14)	IHS(FDI 05-14)	IHS(FDI05-14)	IHS(FDI05-14)	MOD05-14	MAN05-14	MOD05-14	MAN05-14
$D[\Delta \text{ metro density} > 0]$	1.025***	1.001***			0.872***	-0.127		
	(0.305)	(0.241)			(0.258)	(0.221)		
$D[\Delta \text{ metro density} > \text{median}]$			1.030***	0.887***			0.607*	-0.112
			(0.349)	(0.255)			(0.345)	(0.264)
FDI 2003-04	0.036***	0.037***	0.022***	0.020***				
	(0.003)	(0.002)	(0.003)	(0.002)				
MOD 2003-04					0.054***		0.054***	
					(0.009)		(0.013)	
MAN 2003-04						0.121**		0.063**
						(0.048)		(0.027)
Metro density 2004	-0.294	-0.521	-0.638	-0.698	-1.937	-0.754	-2.324***	-0.191
	(1.431)	(0.960)	(1.251)	(0.673)	(1.313)	(0.836)	(0.749)	(1.007)
ln(GVApc 2000)	0.589***	0.565***	0.783***	0.679***	1.085***	0.454**	1.293***	0.689*
	(0.171)	(0.081)	(0.130)	(0.061)	(0.132)	(0.215)	(0.136)	(0.381)
ln(Population 2000)	0.834***	0.811***	0.926***	0.936***	1.045***	1.035***	1.196***	1.245***
	(0.048)	(0.072)	(0.048)	(0.075)	(0.124)	(0.160)	(0.123)	(0.124)
Capital city	-0.071	-0.029	0.133	0.138	0.334*	-0.738***	0.546***	-0.925***
	(0.156)	(0.140)	(0.141)	(0.130)	(0.184)	(0.236)	(0.204)	(0.309)
Airport	-0.056	0.013	-0.113	0.202**	0.194	-0.194	0.057	-0.409**
	(0.192)	(0.075)	(0.197)	(0.084)	(0.176)	(0.224)	(0.183)	(0.167)
Port	0.030	0.064	0.474**	0.462***	0.139	-0.028	0.264	-0.037
	(0.145)	(0.070)	(0.205)	(0.088)	(0.147)	(0.176)	(0.205)	(0.213)
Rail density 2004	-0.015	-0.015	-0.026	-0.033	0.301**	-0.030	0.045	0.031
	(0.035)	(0.019)	(0.024)	(0.021)	(0.149)	(0.113)	(0.162)	(0.172)
Observations	3,477	3,477	3,478	3,478	3,484	3,479	3,476	3,489
R-squared	0.848	0.847	0.846	0.837				
Cont. dummies	YES	YES	YES	YES	YES	YES	YES	YES
CRE	YES	YES	YES	YES	YES	YES	YES	YES
First stage F-stat		8.249		9.432				
Over id test - p-val		0.486		0.901				
Pseudo R2					0.208	0.219	0.220	0.241

Cluster-robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

WOLS: Weighted OLS; WIV: Weighted IV; WNBRM: Weighted Negative Binomial Regression Model.

Weights are obtained from multivariate distance matching (kmatch command in Stata).

Lastly, not all FDI activities should be attracted by a metro. Tanaka (2019) shows that multinationals requiring more face-to-face communication are more sensitive to higher international flight frequencies in their location choices. Glaeser (1998) and Glaeser and Kohlhase (2004) highlight that time is a substantial and limiting factor in services, highly-skilled and/or involving face-to-face interactions. A dense urban transport infrastructure can reduce time costs (i.e. income foregone while moving). On the other hand, other activities do not need necessarily need to have an easy and fast access to city centres, e.g. manufacturing. Hence, finding that the former activities are more sensitive to a metro shock than the latter activities would reinforce the causal nature of our estimates. To carry out this kind of placebo test, in columns (5) and (7) we use as dependent variable FDI in most likely 'metro-demanding central activities', i.e. modern services (business services; headquarters; sales, marketing and support) while in column (6) and (8) we use as dependent variable FDI a typical 'peripheral activity', i.e. manufacturing. Comparing columns (5) and (7) with columns (6) and (8) highlights that it is only FDI in modern services which is positively influenced by a metro shock, suggesting once again that the metro shock is not a proxy for an unobserved positive city attribute.

Overall, in line with Chatman and Noland (2014), our results support the idea that a more extensive metro system play a 'causal' role in city attractiveness by decreasing commuting costs and improving accessibility. While we do not investigate this in our empirical analysis, better urban transport infrastructure may also induce stronger agglomeration economies.

5 Conclusion

In this paper, using an original city-level database, we shown that expanding metro infrastructure improves the attractiveness of cities in the form of greater greenfield foreign direct investment (FDI) received over the period 2005-2014. A natural explanation is that a metro system improves accessibility and commuting speed.

Our study has focused on foreign direct investment but we naturally do not claim that metros ought to be built for the sole purpose of attracting foreign investors. The influence of metro systems on the location choice of multinational firms should rather be interpreted as revealing whether such an investment in public transport infrastructure contributes to improving a city's attractiveness, which may benefit all firms and individuals, be they foreign or native. While we conclude by the affirmative, a thorough and extensive cost-benefit evaluation is still required to assess the social value of investing in the development of metro networks.

References

Allison, Paul D. and Waterman, Richard P. (2002) 'Fixed-effects Negative Binomial Regression Models', *Sociological Methodology*, Vol. 32, pp. 247–265.

Angrist, Joshua D. and Pischke, Jörn-Steffen (2009) *Mostly Harmless Econometrics: An Empiricist's Companion*: Princeton: Princeton University Press.

Basile, Roberto, Castellani, Davide, and Zanfei, Antonello (2008) 'Location Choices of Multinational Firms in Europe: The Role of EU Cohesion Policy', *Journal of International Economics*, Vol. 74, pp. 328 – 340.

Baum-Snow, Nathaniel (2007) 'Did Highways Cause Suburbanization?', *The Quarterly Journal of Economics*, Vol. 122, pp. 775–805.

Baum-Snow, Nathaniel and Kahn, Matthew E. (2000) 'The Effects of New Public Projects to Expand Urban Rail Transit', *Journal of Public Economics*, Vol. 77, pp. 241–263.

Baum-Snow, Nathaniel, Kahn, Matthew E., and Voith, Richard (2005) 'Effects of Urban Rail Transit Expansions: Evidence from Sixteen Cities, 1970-2000 [with Comment]', *Brookings-Wharton Papers on Urban Affairs*, pp. 147–206.

Beck, N. and Katz, J.N. (2011) 'Modeling Dynamics in Time-Series-Cross-Section Political Economy Data', *Annual Review of Political Science*, Vol. 14, pp. 331–352.

Bel, Germà and Fageda, Xavier (2008) 'Getting There Fast: Globalization, Intercontinental Flights and Location of Headquarters', *Journal of Economic Geography*, Vol. 8, pp. 471–495.

Blonigen, Bruce A and Piger, Jeremy (2014) 'Determinants of Foreign Direct Investment', *Canadian Journal of Economics*, Vol. 47, pp. 775–812.

Buch, Tanja, Hamann, Silke, Niebuhr, Annekatrin, and Rossen, Anja (2014) 'What Makes Cities Attractive? The Determinants of Urban Labour Migration in Germany', *Urban Studies*, Vol. 51, pp. 1960–1978.

Cameron, Colin A. and Trivedi, Pravin K. (2013) *Regression Analysis of Count Data*: Cambridge: Cambridge University Press, second edition.

Chatman, Daniel G. and Noland, Robert B. (2014) 'Transit Service, Physical Agglomeration and Productivity in US Metropolitan Areas', *Urban Studies*, Vol. 51, pp. 917–937.

Crozet, Matthieu, Mayer, Thierry, and Mucchielli, Jean-Louis (2004) 'How do firms agglomerate? A study of FDI in France', *Regional Science and Urban Economics*, Vol. 34, pp. 27–54.

Davis, James C. and Henderson, J. Vernon (2008) 'The agglomeration of headquarters', *Regional Science and Urban Economics*, Vol. 38, pp. 445 – 460, In Honor of Masahisa Fujita: A Special Issue.

Defever, Fabrice (2006) 'Functional fragmentation and the location of multinational firms in the enlarged Europe', *Regional Science and Urban Economics*, Vol. 36, pp. 658–677.

Desbordes, Rodolphe and Wei, Shang-Jin (2017) 'The Effects of Financial Development on Foreign Direct Investment', *Journal of Development Economics*, Vol. 127, pp. 153–168.

Donaldson, Dave (2018) 'Railroads of the Raj: Estimating the Impact of Transportation Infrastructure', *American Economic Review*, Vol. 108, pp. 899–934.

Duranton, Gilles and Puga, Diego (2005) 'From sectoral to functional urban specialisation', *Journal of Urban Economics*, Vol. 57, pp. 343 – 370.

Duranton, Gilles and Turner, Matthew A. (2011) 'The Fundamental Law of Road Congestion: Evidence from US Cities', *American Economic Review*, Vol. 101, pp. 2616–52.

——— (2012) 'Urban Growth and Transportation', *The Review of Economic Studies*, Vol. 79, p. 1407.

Fageda, Xavier (2017) ‘International Air Travel and FDI Flows: Evidence From Barcelona’, *Journal of Regional Science*, Vol. 57, pp. 858–883.

Gendron-Carrier, Nicolas, Gonzalez-Navarro, Marco, Polloni, Stefano, and Turner, Matthew A. (2022) ‘Subways and Urban Air Pollution’, *American Economic Journal: Applied Economic*, Vol. 14.

Glaeser, Edward L (1998) ‘Are Cities Dying?’, *Journal of Economic Perspectives*, Vol. 12, pp. 139–160.

Glaeser, Edward L and Kohlhase, Janet E (2004) ‘Cities, Regions and the Decline of Transport Costs’, in *Fifty Years of Regional Science*: Berlin: Springer, pp. 197–228.

Gonzalez-Navarro, Marco and Turner, Matthew A. (2018) ‘Subways and urban growth: Evidence from earth’, *Journal of Urban Economics*, Vol. 108, pp. 85–106.

Guimaraes, Paulo (2008) ‘The Fixed Effects Negative Binomial Model Revisited’, *Economics Letters*, Vol. 99, pp. 63–66.

Guimaraes, Paulo, Figueiredo, Octávio, and Woodward, Douglas (2004) ‘Industrial Location Modeling: Extending the Random Utility Framework’, *Journal of Regional Science*, Vol. 44, pp. 1–20.

Head, Keith and Mayer, Thierry (2004) ‘Market Potential and the Location of Japanese Investment in the European Union’, *Review of Economics and Statistics*, Vol. 86, pp. 959–972.

Ho, Daniel E, Imai, Kosuke, King, Gary, and Stuart, Elizabeth A (2007) ‘Matching as Nonparametric Preprocessing for Reducing Model Dependence in Parametric Causal Inference’, *Political analysis*, Vol. 15, pp. 199–236.

Jann, Ben (2017) ‘Kmatch: Stata module for multivariate-distance and propensity-score matching, including entropy balancing, inverse probability weighting, (coarsened) exact matching, and regression adjustment’, *Boston College Statistical Software Components Archive*.

Javorcik, Beata S (2015) 'Does FDI Bring Good Jobs to Host Countries?', *World Bank Research Observer*, Vol. 30.

King, Gary and Zeng, Langche (2006) 'The Dangers of Extreme Counterfactuals', *Political Analysis*, Vol. 14, pp. 131–159.

King, Robert G and Thomas, Julia K (2006) 'Partial Adjustment Without Apology', *International Economic Review*, Vol. 47, pp. 779–809.

Kummu, Matti, Taka, Maija, and Guillaume, Joseph HA (2018) 'Gridded Global Datasets For Gross Domestic Product and Human Development Index over 1990–2015', *Scientific data*, Vol. 5, pp. 1–15.

Mayer, Thierry and Trevien, Corentin (2017) 'The Impact of Urban Public Transportation: Evidence From the Paris Region', *Journal of Urban Economics*, Vol. 102, pp. 1 – 21.

Melo, Patricia C., Graham, Daniel J., and Brage-Ardao, Ruben (2013) 'The productivity of transport infrastructure investment: A meta-analysis of empirical evidence', *Regional Science and Urban Economics*, Vol. 43, pp. 695 – 706.

Morgan, Stephen L and Winship, Christopher (2015) *Counterfactuals and Causal Inference*: New York: Cambridge University Press, second edition.

Nielsen, Bo Bernhard, Asmussen, Christian Geisler, and Weatherall, Cecilie Dohlmann (2017) 'The Location Choice of Foreign Direct Investments: Empirical Evidence and Methodological Challenges', *Journal of World Business*, Vol. 52, pp. 62–82.

O´ Neill, Stephen, Kreif, Noémi, Grieve, Richard, Sutton, Matthew, and Sekhon, Jasjeet S. (2016) 'Estimating Causal Effects: Considering Three Alternatives to Difference-in-Differences Estimation', *Health Services and Outcomes Research Methodology*, Vol. 16, pp. 1–21.

Potere, David, Schneider, Annemarie, Angel, Shlomo, and Civco, Daniel L (2009) 'Mapping Urban Areas on a Global Scale: Which of the Eight Maps Now Available is More Accurate?', *International Journal of Remote Sensing*, Vol. 30, pp. 6531–6558.

Py, Loriane and Hatem, Fabrice (2010) ‘Internationalization and Location of Services: a Sectoral and Functional Analysis Applied to Multinational Firms in Europe’, *Economie & Statistique*, Vol. 426, pp. 67–95.

Strauss-Kahn, Vanessa and Vives, Xavier (2009) ‘Why and Where Do Headquarters Move?’, *Regional Science and Urban Economics*, Vol. 39, pp. 168–186.

Tanaka, Kiyoyasu (2019) ‘Do International Flights Promote FDI? The Role of Face-to-Face Communication’, *Review of International Economics*, Vol. 27, pp. 1609–1632.

Winkelmann, Rainer (2008) *Econometric Analysis of Count Data*: Berlin: Springer-Verlag Berlin Heidelberg.

Wooldridge, Jeffrey (1999) ‘Distribution-free Estimation of Some Nonlinear Panel Data Models’, *Journal of Econometrics*, Vol. 90, pp. 77–97.

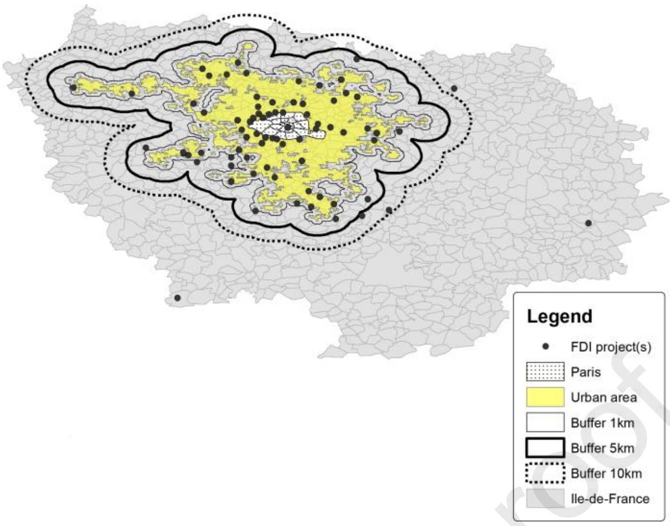
Appendices

Appendix A Online appendix

A.1 The use of buffers to define cities: the example of Paris

Figure 4 illustrates the meaning of using various buffers to define the limits of a city in the case of Paris. The white area represents the administrative borders of the city of Paris. The yellow area represents the urbanised area of Paris which goes well beyond its administrative border. The thin black line represents the 1 km buffer, the thick black line, the 5 km buffer, and the doted line the 10 km buffer. Some FDI projects are located in or just at the borders of the urban areas (note that a dot represents the existence of at least one FDI project in the considered city, as delimited by the light grey lines). There are actually $1,448$ FDI projects (over the period 2003-2014) within the 1 km buffer around the Parisian urban area and this number increases by 13 projects when considering the 5 km buffer. The buffers around the city appear therefore quite relevant for the analysis.[28]

Figure 4: *FDI* in Paris, France



A.2 World distribution of urban FDI

Figure 5 shows the world distribution of urban FDI over the period 2003-2014, focusing on cities which have attracted at least ten projects.

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[28] Buffers also allow us to deal with issues such as urban areas with a large fraction of unbuildable land (e.g. a park or a lake) at their centre. In rare cases, when buffers overlap, some FDI are counted more than once for urban areas close to each other. It is possible that this ‘dual location’ is deliberate.

Figure 5: World distribution of urban *FDI*

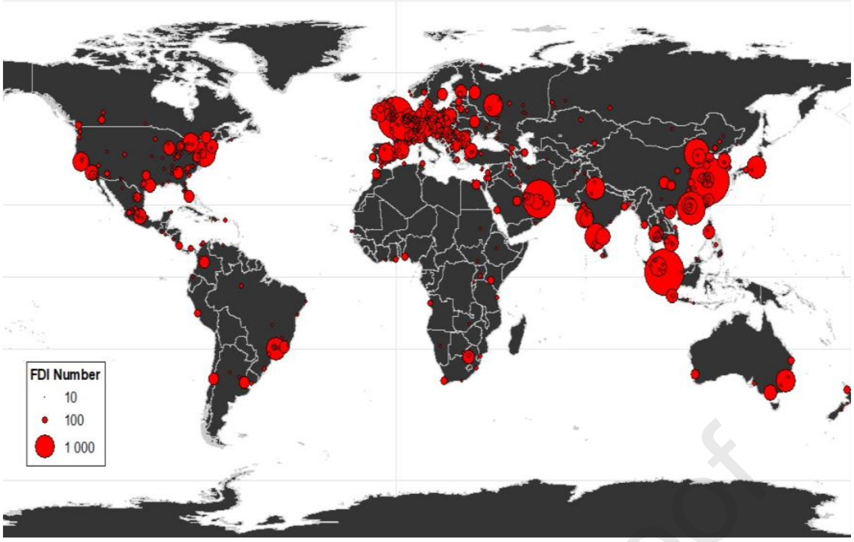


Table 8 presents the main investing and receiving countries in terms of number of outward and inward FDI projects. Overall, the United States, the United Kingdom, and Germany are the top three investing countries. China ranks first in terms of number of inward FDI, attracting 12.5% of world total FDI over the period of study.

Table 8: Main origin and destination countries of urban FDI

Top origin countries	% of total	Top Destination country	% of total
United States	24%	China	12.3%
United Kingdom	9.0%	United States	9.08%
Germany	8.9%	United Kingdom	5.99%
Japan	7.5%	India	5.75%
France	5.2%	Germany	4.93%
Switzerland	3.0%	France	3.00%
Canada	2.8%	Russia	2.7%
t Spain	2.8%	Spain	2.3%
Netherlands	2.7%	Canada	1.9%
China	2.3%	Japan	1.2%
India	2.3 %	Netherlands	1.2%
Italy	2.0%	Italy	1.05%

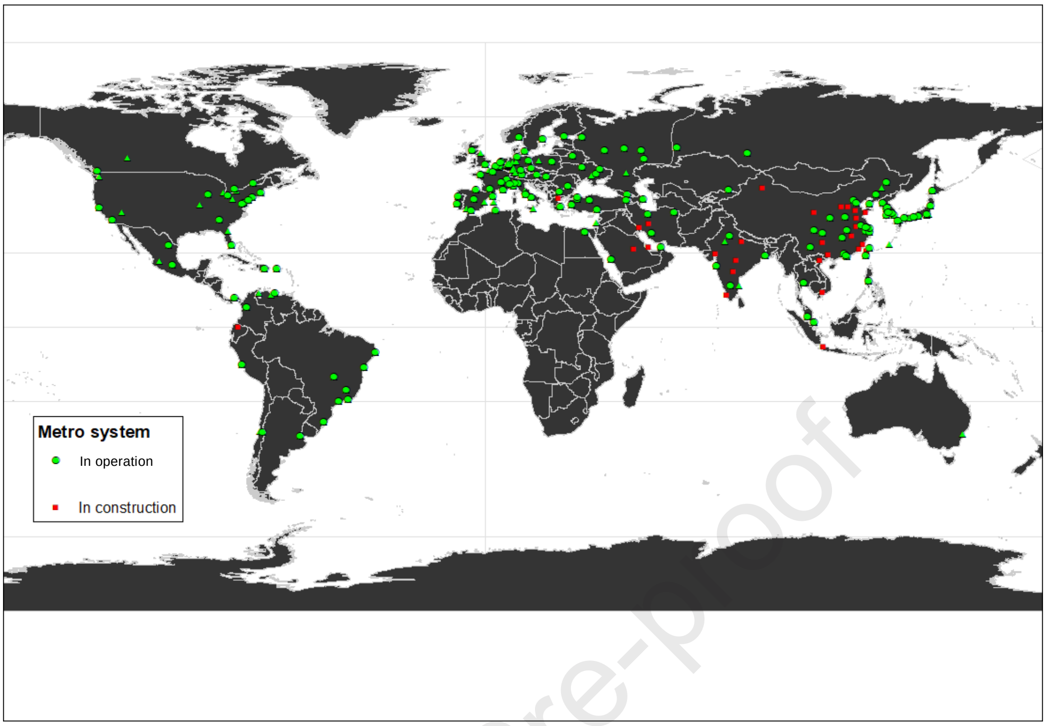
A.3 List of cities with a metro in operation in 2014

Table 9: List of cities with a metro network in 2014

Continent	Country	Urban Area	Continent	Country	Urban Area
Africa	Algeria	Algiers	Europe	Austria	Vienna
Africa	Egypt	Cairo	Europe	Belarus	Minsk
Asia	Armenia	Yerevan	Europe	Belgium	Antwerpen
Asia	Azerbaijan	Baku	Europe	Belgium	Brussels
Asia	China	Beijing	Europe	Belgium	Charleroi
Asia	China	Changchun	Europe	Bulgaria	Sofia
Asia	China	Changsha	Europe	Czech Republic	Prague
Asia	China	Chengdu	Europe	Denmark	Copenhagen
Asia	China	Chongqing	Europe	Finland	Helsinki
Asia	China	Dalian	Europe	France	Lille
Asia	China	Foshan	Europe	France	Lyon
Asia	China	Guangzhou	Europe	France	Marseille
Asia	China	Hangzhou	Europe	France	Paris
Asia	China	Harbin	Europe	France	Rennes
Asia	China	Hong-Kong	Europe	France	Rouen
Asia	China	Kaohsiung, Taiwan	Europe	France	Toulouse
Asia	China	Kunming	Europe	Germany	Berlin
Asia	China	Nanjing	Europe	Germany	Bielefeld
Asia	China	Ningbo	Europe	Germany	Bochum
Asia	China	Shanghai	Europe	Germany	Bonn
Asia	China	Shenyang	Europe	Germany	Cologne
Asia	China	Shenzhen	Europe	Germany	Dortmund
Asia	China	Suzhou (Jiangsu)	Europe	Germany	Duisburg
Asia	China	Taipei, Taiwan	Europe	Germany	Dusseldorf
Asia	China	Tianjin	Europe	Germany	Essen
Asia	China	Wuhan	Europe	Germany	Frankfurt
Asia	China	Wuxi	Europe	Germany	Hamburg
Asia	China	Xian	Europe	Germany	Hannover
Asia	China	Zhengzhou	Europe	Germany	Munich
Asia	Georgia	Tbilisi	Europe	Germany	Nuremberg
Asia	India	Bangalore	Europe	Germany	Stuttgart
Asia	India	Chennai	Europe	Germany	Wuppertal
Asia	India	Delhi	Europe	Greece	Athens
Asia	India	Kolkota	Europe	Hungary	Budapest
Asia	India	Mumbai	Europe	Italy	Brescia
Asia	Iran	Mashhad	Europe	Italy	Catania
Asia	Iran	Shiraz	Europe	Italy	Genoa
Asia	Iran	Teheran	Europe	Italy	Milano
Asia	Israel	Haifa	Europe	Italy	Napoli (Naples)
Asia	Japan	Fukuoka	Europe	Italy	Perugia
Asia	Japan	Hiroshima	Europe	Italy	Rome
Asia	Japan	Kitakyushu	Europe	Italy	Turin
Asia	Japan	Nagoya	Europe	Netherlands	Amsterdam
Asia	Japan	Naha	Europe	Netherlands	Rotterdam
Asia	Japan	Osaka	Europe	Netherlands	The Hague
Asia	Japan	Sapporo	Europe	Norway	Oslo
Asia	Japan	Sendai	Europe	Poland	Poznan
Asia	Japan	Tokyo	Europe	Poland	Warszawa
Asia	Kazakhstan	Almaty	Europe	Portugal	Lisboa
Asia	Korea, Dem. Rep.	Pyongyang	Europe	Portugal	Porto
Asia	Korea, Rep.	Kwangju	Europe	Romania	Bucharest
Asia	Korea, Rep.	Pusan	Europe	Russia	Kazan
Asia	Korea, Rep.	Suwon	Europe	Russia	Moscow
Asia	Korea, Rep.	Taegu	Europe	Russia	Nizhni Novgorod
Asia	Korea, Rep.	Taejon	Europe	Russia	Saint Petersburg
Asia	Malaysia	Kuala Lumpur	Europe	Russia	Samara
Asia	Philippines	Metro Manila	Europe	Russia	Volgograd
Asia	Russia	Ekaterinburg	Europe	Spain	Barcelona
Asia	Russia	Novosibirsk	Europe	Spain	Bilbao
Asia	Saudi Arabia	Mecca	Europe	Spain	Madrid
Asia	Singapore	Singapore	Europe	Spain	Malaga
Asia	Thailand	Bangkok	Europe	Spain	Palma de Mallorca
Asia	Turkey	Adana	Europe	Spain	Sevilla
Asia	Turkey	Ankara	Europe	Spain	Valencia
Asia	Turkey	Bursa	Europe	Sweden	Stockholm
Asia	Turkey	Istanbul	Europe	Switzerland	Lausanne
Asia	Turkey	Izmir	Europe	Ukraine	Dnepropetrovsk
Asia	United Arab Emirates	Dubai	Europe	Ukraine	Kharkov
Asia	Uzbekistan	Tashkent	Europe	Ukraine	Kiev
			Europe	Ukraine	Krivoi Rog
			Europe	United Kingdom	Glasgow
			Europe	United Kingdom	London
			Europe	United Kingdom	Newcastle upon Tyne

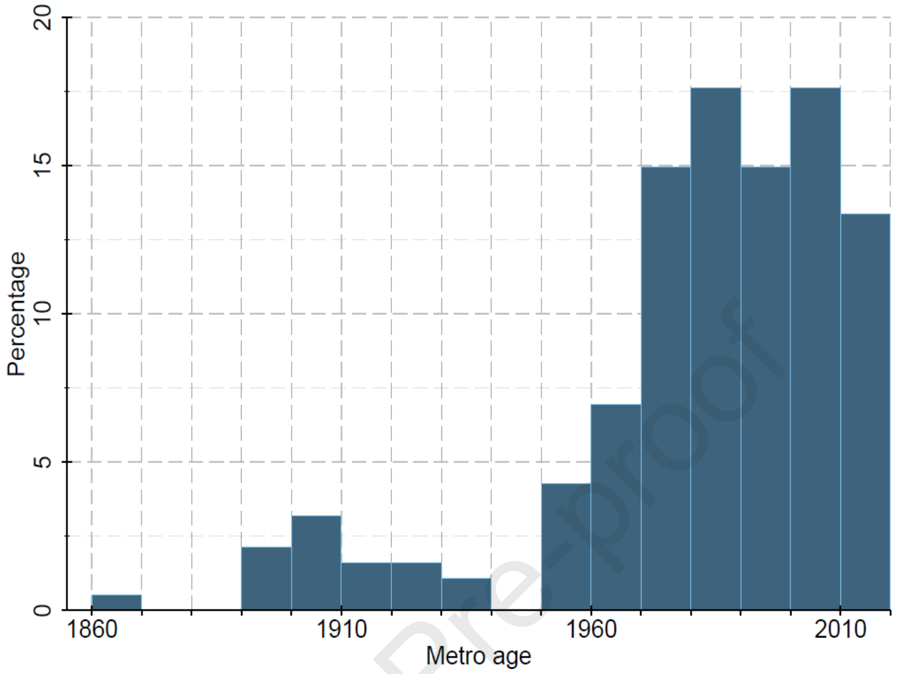
Continent	Country	Urban Area
North America	Canada	Edmonton
North America	Canada	Montreal
North America	Canada	Toronto
North America	Canada	Vancouver
North America	Dominican Republic	Santo Domingo
North America	Mexico	Guadalajara
North America	Mexico	Mexico
North America	Mexico	Monterrey
North America	Puerto Rico	San Juan
North America	United States	Atlanta
North America	United States	Baltimore
North America	United States	Boston
North America	United States	Buffalo NY
North America	United States	Chicago
North America	United States	Cleveland
North America	United States	Detroit
North America	United States	Jacksonville, FL MSA
North America	United States	Las Vegas
North America	United States	Los Angeles
North America	United States	Miami
North America	United States	New-York
North America	United States	Philadelphia
North America	United States	Pittsburgh, PA MSA
North America	United States	San Francisco
North America	United States	Seattle
North America	United States	St. Louis, MO–IL MSA
North America	United States	Washington
Oceania	Australia	Sydney
South America	Argentina	Buenos Aires
South America	Brazil	Belo Horizonte
South America	Brazil	Brasilia
South America	Brazil	Porto Alegre
South America	Brazil	Recife
South America	Brazil	Rio de Janeiro
South America	Brazil	Salvador
South America	Brazil	Sao Paolo
South America	Chile	Santiago
South America	Chile	Vina del Mar
South America	Colombia	Medellin
South America	Panama	Panama City
South America	Peru	Lima
South America	Venezuela	Caracas
South America	Venezuela	Maracaibo
South America	Venezuela	Valencia

Figure 6: World location of metro systems in 2014



A.4 Year of creation of metro systems in the world

Figure 7: Year of creation of metro systems in the world



A.5 Balancing diagnostics

Table 10: Positive metro extension - Mean

	Treated	Untreated	StdDif	Treated	Untreated	StdDif
Metro density 2004	.081	.002	1.05	.038	.001	.482
FDI 2003-04	38.922	1.059	.677	13.961	.998	.232
ln(GVApc 2000)	9.665	8.901	.737	9.505	8.894	.589
ln(Population 2000)	14.821	12.454	2.547	14.565	12.457	2.269
Capital city	.297	.027	.783	.041	.017	.07
Airport	.766	.137	1.627	.643	.128	1.332
Port	.414	.077	.849	.316	.071	.616
Rail density 2004	.501	.841	-.51	.511	.839	-.49
continent==Asia	.398	.523	-.251	.481	.532	-.102
continent==Europe	.383	.177	.469	.333	.178	.354
continent==North America	.086	.11	-.079	.095	.108	-.045
continent==South America	.117	.077	.134	.089	.078	.036
country average(D[Δ metro density > 0])	.09	.034	.681	.065	.035	.368
country average(metro density 2004)	.012	.004	.368	.007	.004	.148
country average(FDI 2003-04)	5.52	2.321	.18	2.728	2.266	.026
country average(ln(GVApc 2000))	9.469	8.909	.561	9.407	8.903	.504
country average(ln(Population 2000))	12.556	12.54	.056	12.519	12.538	-.067
country average(Capital city)	.042	.037	.048	.017	.027	-.092
country average(Airports)	.178	.159	.135	.149	.151	-.009
country average(Port)	.13	.087	.315	.103	.081	.156
country average(Rail density 2004)	.938	.825	.259	.891	.831	.137

Table 11: Positive metro extension - Variance

	Treated	Untreated	Ratio	Treated	Untreated	Ratio
Metro density 2004	.011	.001	15.077	.002	0	6.928
FDI 2003-04	6238.907	21.515	289.984	283.277	19.42	14.587
ln(GVApc 2000)	.877	1.269	.691	.962	1.241	.775
ln(Population 2000)	.888	.839	1.059	.659	.806	.818
Capital city	.21	.027	7.878	.04	.017	2.344
Airport	.181	.118	1.532	.231	.112	2.071
Port	.245	.071	3.45	.218	.066	3.303
Rail density 2004	.137	.757	.181	.111	.67	.166
continent==Asia	.242	.25	.968	.252	.249	1.011
continent==Europe	.238	.146	1.631	.224	.146	1.533
continent==North America	.079	.098	.812	.087	.096	.898
continent==South America	.104	.071	1.461	.081	.072	1.133
country average(D[Δ metro density > 0])	.012	.001	8.072	.002	.001	1.512
country average(metro density 2004)	.001	0	5.087	0	0	1.571
country average(FDI 2003-04)	629.953	5.109	123.305	3.147	3.825	.823
country average(ln(GVApc 2000))	.878	1.125	.781	.931	1.102	.845
country average(ln(Population 2000))	.087	.075	1.155	.02	.058	.339
country average(Capital city)	.011	.011	.974	.001	.003	.172
country average(Airports)	.019	.02	.979	.012	.014	.848
country average(Port)	.023	.015	1.533	.01	.01	1.044
country average(Rail density 2004)	.223	.163	1.369	.171	.156	1.094

Table 12: Metro extension above Q1 - Mean

	Treated	Untreated	StdDif	Treated	Untreated	StdDif
Metro density 2004	.079	.002	.926	.031	.002	.345
FDI 2003-04	38.344	1.43	.607	13.529	1.56	.197
ln(GVApc 2000)	9.516	8.912	.577	9.349	8.91	.42
ln(Population 2000)	14.727	12.479	2.392	14.515	12.485	2.16
Capital city	.281	.03	.734	.044	.022	.065
Airport	.729	.144	1.458	.607	.138	1.169
Port	.396	.08	.794	.282	.076	.519
Rail density 2004	.472	.839	-.547	.479	.836	-.532
continent==Asia	.479	.52	-.081	.592	.526	.133
continent==Europe	.333	.181	.354	.271	.181	.207
continent==North America	.063	.11	-.169	.065	.109	-.157
continent==South America	.104	.078	.091	.068	.078	-.035
country average(D[Δ metro density > 25%])	.09	.026	.712	.058	.026	.354
country average(metro density 2004)	.013	.004	.355	.006	.004	.106
country average(FDI 2003-04)	6.006	2.337	.179	2.64	2.301	.017
country average(ln(GVApc 2000))	9.324	8.918	.406	9.247	8.917	.33
country average(ln(Population 2000))	12.557	12.54	.057	12.51	12.539	-.096
country average(Capital city)	.047	.037	.092	.017	.027	-.089
country average(Airports)	.169	.159	.067	.132	.152	-.136
country average(Port)	.128	.088	.275	.095	.083	.085
country average(Rail density 2004)	.879	.827	.119	.839	.834	.013

Table 13: Metro extension above Q1 - Variance

	Treated	Untreated	Ratio	Treated	Untreated	Ratio
Metro density 2004	.013	.001	16.423	.002	0	4.825
FDI 2003-04	7337.807	63.672	115.243	333.141	109.534	3.041
ln(GVApc 2000)	.91	1.275	.714	.985	1.251	.788
ln(Population 2000)	.863	.904	.954	.641	.881	.728
Capital city	.204	.029	6.926	.042	.021	2.011
Airport	.2	.123	1.623	.241	.119	2.032
Port	.242	.074	3.267	.205	.07	2.91
Rail density 2004	.151	.751	.202	.111	.664	.167
continent==Asia	.252	.25	1.01	.244	.249	.979
continent==Europe	.225	.148	1.516	.2	.149	1.344
continent==North America	.059	.098	.605	.062	.097	.634
continent==South America	.094	.072	1.31	.064	.072	.889
country average(D[Δ metro density > 25%])	.015	.001	12.269	.002	.001	1.653
country average(metro density 2004)	.001	0	6.55	0	0	1.561
country average(FDI 2003-04)	835.84	5.238	159.573	3.148	4.156	.757
country average(ln(GVApc 2000))	.878	1.129	.777	.916	1.109	.827
country average(ln(Population 2000))	.112	.075	1.503	.022	.058	.376
country average(Capital city)	.014	.011	1.262	.001	.004	.179
country average(Airports)	.022	.02	1.124	.011	.015	.766
country average(Port)	.027	.015	1.842	.011	.01	1.063
country average(Rail density 2004)	.22	.164	1.338	.159	.158	1.006

Table 14: Metro extension above Q2 - Mean

	Treated	Untreated	StdDif	Treated	Untreated	StdDif
Metro density 2004	.076	.003	.773	.022	.003	.195
FDI 2003-04	45.078	1.647	.594	13.99	1.789	.167
ln(GVApc 2000)	9.376	8.921	.441	9.152	8.921	.224
ln(Population 2000)	14.733	12.5	2.291	14.554	12.506	2.101
Capital city	.25	.033	.649	.052	.025	.082
Airport	.609	.151	1.065	.476	.146	.767
Port	.344	.084	.663	.204	.081	.313
Rail density 2004	.423	.836	-.618	.407	.831	-.633
continent==Asia	.594	.517	.154	.704	.522	.365
continent==Europe	.281	.183	.233	.24	.184	.134
continent==North America	.031	.11	-.311	.016	.109	-.367
continent==South America	.094	.079	.054	.04	.079	-.137
country average(D[Δ metro density > 50%])	.085	.017	.712	.052	.017	.365
country average(metro density 2004)	.013	.004	.326	.006	.004	.061
country average(FDI 2003-04)	7.252	2.348	.196	2.661	2.325	.013
country average(ln(GVApc 2000))	9.188	8.924	.261	9.029	8.925	.103
country average(ln(Population 2000))	12.54	12.54	-.001	12.48	12.54	-.18
country average(Capital city)	.045	.037	.067	.017	.027	-.085
country average(Airports)	.151	.16	-.058	.104	.153	-.325
country average(Port)	.127	.088	.261	.083	.085	-.013
country average(Rail density 2004)	.839	.829	.023	.776	.833	-.128

Table 15: Metro extension above Q2 - Variance

	Treated	Untreated	Ratio	Treated	Untreated	Ratio
Metro density 2004	.017	.001	19.02	.002	.001	3.18
FDI 2003-04	10634.93	73.459	144.774	371.133	118.527	3.131
ln(GVApc 2000)	.849	1.279	.664	.908	1.26	.721
ln(Population 2000)	.951	.948	1.003	.684	.928	.738
Capital city	.19	.032	5.913	.05	.024	2.078
Airport	.242	.128	1.883	.254	.125	2.036
Port	.229	.077	2.968	.165	.075	2.206
Rail density 2004	.15	.746	.201	.072	.661	.109
continent==Asia	.245	.25	.981	.212	.25	.85
continent==Europe	.205	.15	1.373	.186	.15	1.238
continent==North America	.031	.098	.314	.016	.097	.163
continent==South America	.086	.072	1.193	.039	.073	.542
country average(D[Δ metro density > 50%])	.017	.001	20.623	.002	.001	1.981
country average(metro density 2004)	.001	0	9.051	0	0	1.656
country average(FDI 2003-04)	1247.79	5.346	233.407	3.358	4.431	.758
country average(ln(GVApc 2000))	.922	1.129	.816	.908	1.114	.815
country average(ln(Population 2000))	.145	.075	1.942	.021	.058	.364
country average(Capital city)	.017	.011	1.601	.001	.004	.193
country average(Airports)	.026	.02	1.311	.009	.015	.573
country average(Port)	.03	.015	2.057	.01	.011	.952
country average(Rail density 2004)	.236	.164	1.434	.138	.159	.869

Table 16: Metro extension above Q3 - Mean

	Treated	Untreated	StdDif	Treated	Untreated	StdDif
Metro density 2004	.063	.004	.594	.015	.004	.11
FDI 2003-04	67.594	1.839	.689	22.541	1.87	.217
ln(GVApc 2000)	9.153	8.927	.219	8.936	8.925	.011
ln(Population 2000)	14.887	12.519	2.501	14.706	12.522	2.307
Capital city	.156	.036	.411	.012	.025	-.047
Airport	.563	.156	.926	.385	.148	.539
Port	.375	.086	.721	.231	.082	.373
Rail density 2004	.341	.833	-.786	.362	.83	-.748
continent==Asia	.75	.516	.496	.796	.522	.582
continent==Europe	.188	.185	.007	.171	.185	-.036
continent==North America	.031	.109	-.308	.001	.109	-.426
continent==South America	.031	.079	-.21	.032	.08	-.209
country average(D[Δ metro density > 75%])	.074	.009	.527	.031	.009	.184
country average(metro density 2004)	.017	.004	.351	.005	.004	.038
country average(FDI 2003-04)	11.653	2.353	.263	2.637	2.319	.009
country average(ln(GVApc 2000))	8.916	8.929	-.013	8.723	8.928	-.199
country average(ln(Population 2000))	12.573	12.54	.08	12.467	12.539	-.175
country average(Capital city)	.052	.037	.103	.011	.028	-.119
country average(Airports)	.128	.16	-.192	.076	.153	-.469
country average(Port)	.114	.089	.154	.06	.084	-.146
country average(Rail density 2004)	.79	.829	-.098	.769	.834	-.163

Table 17: Metro extension above Q3 - Variance

	Treated	Untreated	Ratio	Treated	Untreated	Ratio
Metro density 2004	.019	.001	17.16	.002	.001	2.318
FDI 2003-04	18127.346	98.474	184.083	667.933	111.699	5.98
ln(GVApc 2000)	.856	1.278	.669	.783	1.259	.622
ln(Population 2000)	.804	.988	.814	.614	.963	.637
Capital city	.136	.035	3.903	.012	.025	.486
Airport	.254	.132	1.93	.245	.126	1.938
Port	.242	.079	3.064	.184	.075	2.439
Rail density 2004	.043	.742	.058	.035	.66	.052
continent==Asia	.194	.25	.775	.168	.25	.672
continent==Europe	.157	.151	1.043	.147	.151	.971
continent==North America	.031	.097	.321	.001	.097	.008
continent==South America	.031	.073	.428	.032	.073	.437
country average(D[Δ metro density > 75%])	.03	0	106.066	.001	0	1.856
country average(metro density 2004)	.003	0	17.176	0	0	2.116
country average(FDI 2003-04)	2490.429	5.347	465.733	1.19	4.36	.273
country average(ln(GVApc 2000))	1.014	1.128	.899	.831	1.112	.748
country average(ln(Population 2000))	.266	.074	3.586	.017	.059	.284
country average(Capital city)	.032	.011	2.921	0	.004	.09
country average(Airports)	.035	.02	1.771	.006	.015	.398
country average(Port)	.039	.015	2.603	.009	.011	.879
country average(Rail density 2004)	.151	.166	.912	.106	.161	.66

- We investigate the impact of metro systems on city attractiveness
- City attractiveness is measured by the number of FDI projects received
- We find that a city improving its metro network is more attractive

Conflict of Interest and Authorship Conformation Form

Please check the following as appropriate:

- ○ X All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version.
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None.	